Mars Millenium Project Materials - Primary Grades K-2
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Introduction

Human beings have long been fascinated with the stars, planets and galaxies within the universe, beyond Earth, sometimes called our Blue Planet. Today we have seen that the impossible has come within reach, the difficult has become reality. As we approach a new millennium, aware that the journeys of the past lead to visions of the future, we offer these primary units for teachers to engage students in experiencing these possibilities.

These materials will provide ideas and resources for teachers with different purposes and timelines. Some of the learning experiences are naturally congruent with curriculum goals, while others will integrate, or expand, the content knowledge. The materials support students in addressing the questions: What do we need for survival? What makes life meaningful? What makes a good community? The materials are designed to complement each other so teachers may use them in an early-years' setting or as students approach the end of the primary years. Faculties may also decide to incorporate a school-wide theme by using the intermediate units which are also available in this same format. In addition, the time management section offers suggestions for adapting the materials for a week, a month, or a year. Many of the activities lend themselves to parent and community participation, reflecting a desire to involve all stakeholders in considering these questions for the next millennium: Who are we? What shall we become? Where will our journey lead?

Link to Content Standards

These materials can be used to help your students meet some of the national content standards. The list below has been selected from *Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education* McREL/ASCD (http://ww.mcrel.org).

Arts

Understands dance as a way to create and communicate meaning.
Sings alone and with others.
Understands the relationship between music, history, and culture.
Understand visual arts in relationship to history and cultures.
Understands the characteristics and merits of ones own artwork and that of others.

Behavioral Studies

Understands various meanings of social groups, group membership, and group functions.

Geography

Knows the location of places, geographic features and patterns in environment.
Understands the patterns of human settlement and their causes.
Understands how human interactions modify the environment.

History

Understands the causes and nature of movements of people into and within the U.S.
Understands significant people, events, problems or ideas.

Language Arts

Gathers and understands information by reading, listening, viewing.

Math

Understands/applies basic concepts of probability and statistics.
Applies methods of measurement.

Science

Understands basic features of Earth.
Understands basic earth processes.
Understands essential ideas about the composition of the universe.
Knows about the diversity and unity that characterize life.
Knows the genetic basis for the transfer of biological characteristics from one generation to another.
Understands how species depend on one another and on the environment for survival.
Understands the cycling of matter and flow of energy.

Unit Title: Who are We?
Grade Level: K-2
Subject: Interdisciplinary
Time Frame: 8 weeks

Link to National Content Standards:

Art- Knows characteristics of and creates artwork.
Behavioral Studies- Understands belonging to groups by birth and choice.
Language Arts- Reads, listens, views and writes to gather and share information
Math- Applies methods of measurement.
Music- Composes and arranges music; sings alone and with others.
Science- Understands diversity/unity of life; flow of energy in food chain.
Dance - Uses movement to express an idea or communicate

Brief Summary of Unit:

Students will understand what it means to be human as they examine physical characteristics, social structures, art as creation and expression, and the ways humans communicate. They will use this information to decide whether they might some day want to live on Mars, the Red Planet. Looking at the natural world around them, they will investigate the food web upon which humans rely for survival and design a basic web that might support them on Mars, given the difference in temperature, water, and soil conditions. Students will simulate a community on Mars, choosing five items to take which represent the essence of their needs and wants as humans, working cooperatively to create the rules and structure for their community, and building a prototype of an ideal community which can be built on Mars.

As a result of this unit, students will understand:

✧ Simple physical characteristics of plants and animals
✧ Living things have similar characteristics and survival needs.
✧ Humans, plants, and animals live together in a community.
✧ The body draws, sings, acts, dances, writes, and speaks.
✧ Communities provide structure to meet basic needs and to enhance the quality of life.
✧ The arts are a means to communicate culture and self.
✧ One's body is his instrument of expression in the arts.

Students will know:

✧ Basic food chain
✧ Similarities and differences between Earth and Mars
✧ Key components of a human social community
✧Simple design and composition in art, dance, and music (rhythm)

Students will be able to:

✧ Create a painting, a dance, or simple musical rhythm to express human spirit in the new Mars community
✧ Differentiate between needs/wants: prepare a backpack for a journey to Mar
✧ Justify plant choices in creating a Marsarium (terrarium)

Essential questions guiding the unit:

✧ What does it mean to be human?
✧ How can we adapt?
✧ What makes a good community?
✧ What can we become?
✧ What do we need to live?
✧ What do we need to be happy?
✧ Can we become whatever we want? What might it mean to be "Martian?"
✧ How can we describe and express ourselves?
✧ How do we relate to others? Animals? Plants?

Student assessments in the unit:

1. Draw simple food chain for humans
2. Create a Marsarium, a prototype terrarium which models converting the arid land of Mars to a habitable biome for humans.
3. Create a painting, musical rhythm, or dance to describe themselves as Mars pioneers.
4. After reading *The Solar System* by Miguel Perez, *Captain Hog* by Daniel Postgate, or *Here*

Come the Aliens by Colin McNaughton, write a book (whole class or individual) to describe Earth as a home to those who live on other planets.
5. Design and construct a building that is essential to a good community, one that you would want to create on Mars.
6. Illustrate/write response to prompts: "What is a human?", "What do human beings need?", "To what groups do you belong?", "What rules are important to live together in harmony?", "What do you know about Mars?", "How would humans need to adapt to Mars?" "How do humans communicate?" "How does movement help people communicate?"

Teaching and learning experiences in the unit:

1. Who am I? Begin with introductions to get to know who they are. Hook them with readings from several books. *I Want to Be* by Thylia Moss uses rich prose to lead us to think of our potential in unusual ways. Lead the students through a series of writings and explorations to define their own humanity. What are human beings? Who can we become? In the sciences, consider the correct names for human bones (skull, elbow, ribs, etc.). How do humans move? What food and shelter do they require? What social groups do they form? What brings them happiness and laughter? When reading books that use cartoons or take children on imaginary voyages to planets, make sure that students understand this is pretend, not real. What do I pretend? Begin to lay the foundation that we create ideas from what we ourselves understand, therefore we imagine ourselves looking for a home on other planets, yet we may come to the understanding that there is "no place like home."

2. What is around me? Study the natural world. What animals and plants are local to your school? Draw and label illustrations of Earth plants/animals. Choose samples to include in a book which describes Earth, our home.

3. What do I need? What do humans eat? What is the food web? Create a simple food web and investigate the possibilities for transporting it to Mars. Ask families to assist by sending in a list of favorite/typical foods eaten. Chart the origins. How much space do we have? How much land is needed to raise a hamburger? What will we eat? Use plastic one or two liter bottles cut in half to create small Marsariums. Use red earth if possible to experiment with creating soil to sustain life. Choose seeds to grow that can feed humans and help create atmosphere. A larger class version may produce radishes, small squash.

4. Where am I? Investigate what we know about the universe and the people from Earth who have traveled into space. Provide information about Mars from the resource list included in this packet. Gather resources in a center for students to do research.

5. Where can I go? Create a Mars shuttle from large boxes. Place simple tools (rulers, calculators, pencils, notepads, scales, etc.) inside the shuttle so students can role play as astronauts and scientists. Photographs of space and views from the shuttle during space travel should be displayed on the inside walls. Create a Martian space base by blowing up a large clear plastic bubble using a fan (see directions at the end of this unit). Decorate with photos of the Martian landscape. Students who visit will bring their backpack of essential items (See below). Generate ideas for furnishing this small space to be habitable for humans.

6. How do I discover? How do I communicate? Explore the senses, the first tools for learning. Investigate hearing through solid, liquid and gas (our atmosphere). If Mars has a thinner atmosphere, how will sound travel and how will we communicate? Explore ways to communicate nonverbally, as Martian atmosphere will not carry sound well. Have students move as though in a different atmosphere; liquid, gas, gooey, etc. Learn hand signals and simple sign language. Turn these into gesture dances.

7. What is a community? Look at the buildings and services in the community. Ask students to consider and justify which are essential. Design a building for the Mars Base. What essential service does it provide? Turn cardboard boxes (cereal, grocery items, etc.) inside out and use them to follow the plans and construct the building designed. Display in the library as the Mars Community. Create rules for getting along with each other. Decide if they will be the same for Mars. Post them in the community.

8. What is essential? Create a paper backpack to fill with essential items to take to the space station. In a home task, ask families to assist students in choosing and packing items of comfort and joy. In the Home Journal, ask adults to record the dialogue with students explaining and justifying their choices. Connect the contents they chose for their back pack to cultural artifacts found in archeological digs on Earth. Who might find your back pack on Mars thousands of years from now?

9. Who am I? What do I want? What makes me happy? What makes us think? Incorporate these answers in pictures, writings, music, dance, and dramas. Provide instruction in musical notation, color mixing, brushstrokes, movement, etc. How did early people capture ideas? Look at petroglyphs from France, Australia. Students can explore how art can capture ideas, feelings, and movement. Look at the works of artists such as Mary Cassatt, (mothers and children), Georgia o'Keefe (the natural world), John Bigger, Wassily Kandinsky (abstract colors as expressions), Henri Matis (movement in paint and paper cutouts), or the sculpture of Caulder (movement) and Henry Moore (ideas and feelings through positive and negative space). Look at the Martian landscape for inspiration and create a painting to express yourself. Simple lines and dashes can express feelings in a rhythm. Listen to space music. Set up musical instruments at a center, teach students simple rhythmic notation. Have students create their own musical rhythm to express selves. Dramas and dance from different cultures preserve heritage for future generations. Create an original dance or drama to record the beginning of the Mars community.

* What can I become? How and when do you become a dancer? A singer? A painter? Before settlers came to America they were British, or French, or Spanish, or Asian, or African. When did they become Americans? If people could live on Mars, would they become Martians? What can you become?

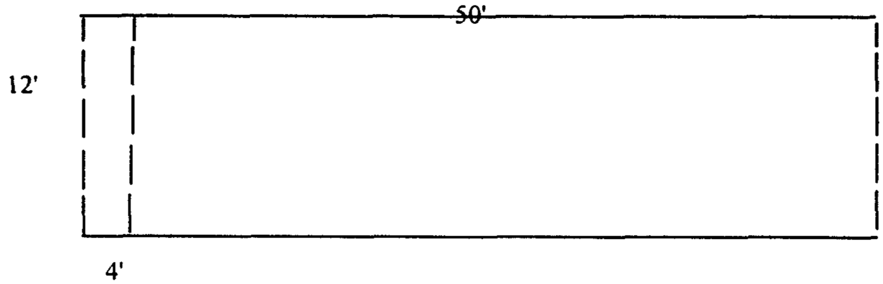
Martian Space Base

Materials:

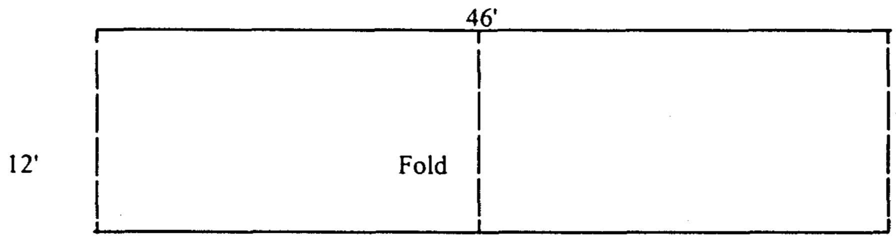
- 12'X 50' roll of polyurethane plastic (black or clear, 4 or 6 mil.)
- large roll of duct tape
- fan (square floor or other fixed type fan)
- brushes and paint, permanent markers
- thread or string, toothpicks, paper clips, etc. (for hanging displays)
- poster board, styrofoam balls, etc. (for decorating)

Procedure:

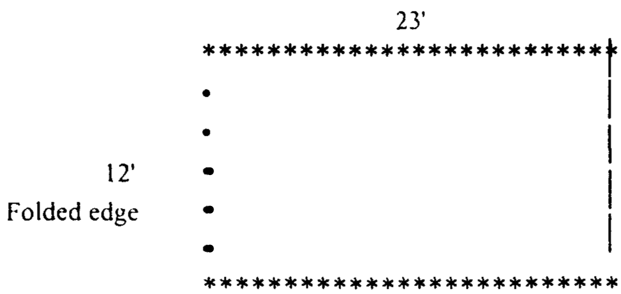
1. Roll out the entire length of plastic.
2. Cut a four foot strip from one end of the roll. This will be used later to make the air duct for inflating the lab.



3. With the entire roll of plastic open and unfolded, fold the two short (12') ends of the long rectangle together.

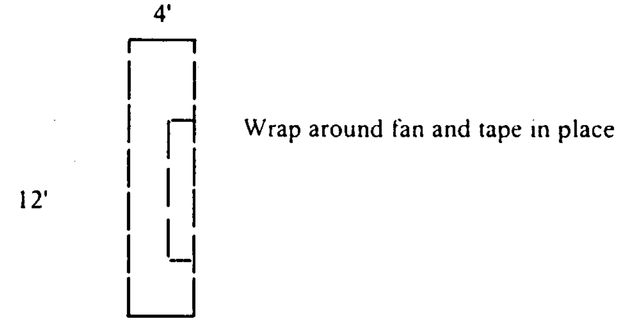


4. Make sure that all edges are even, then tape the two longer edges of the rectangle together using duct tape. This should form a large open ended bag with dimensions of approximately twelve feet by twenty three feet.

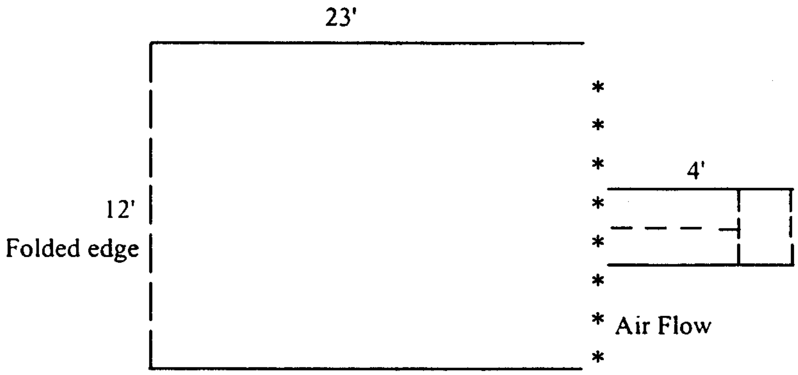


Tape along edge (*) with duct tape

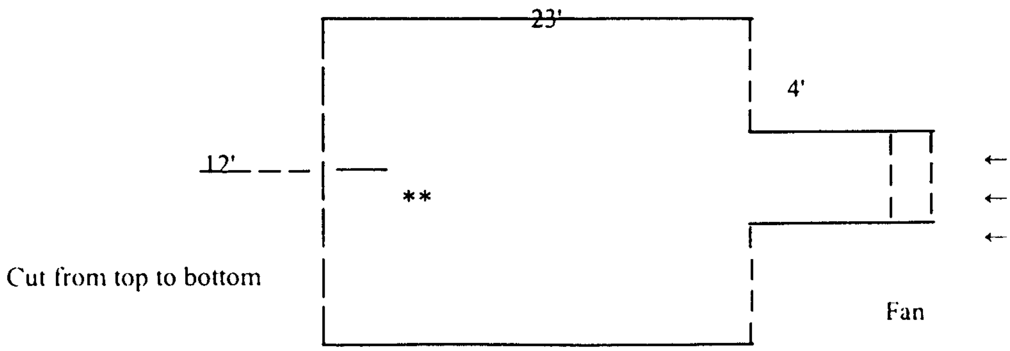
5. Using the four foot strip, which was cut from the original roll of plastic, make an air duct around the floor fan. This can best be accomplished by sitting the fan on the plastic strip and wrapping the plastic around the fan. Tape the plastic to the fan as you proceed. Be sure that the air duct extends on the side of the fan that air blows out from.



6. Attach the air duct to the center of the open end or the large bag using the duct tape. Make sure that the air duct is open from the fan into the bag.



7. Turn the fan on and watch the lab inflate. <u>NOTE: the fan must remain on at all times when the lab is in use to avoid immediate deflation.</u>
8. When the lab is inflated an entrance door may be cut as follows. Make a single slit in the folded (not taped) end of the lab. The slit should run from top to bottom in order to allow an ample passage way for students. The slit/door must be reinforced at each end to avoid tearing.



9. The inside of the lab may be decorated by painting directly on the plastic (this method does not last long with use) or by drawing with permanent markers. Individual items came be made by students and placed in lab. Decorations may be hung using thread or string. Attach string to paperclip, open one end of clip and push through plastic. Once clip is through press together and secure. (This hole should be reinforced with tape so that a tear does not begin)

More Ideas for Teachers to Consider

The acronym WHERE is a way for teachers to think about their curriculum and instruction. W stands for "where" - make sure your students know where the teaching and learning experiences will take them, the goals of the unit and your expectations. H stands for "hook" - hook them with interesting experiences up front to get them excited about learning. E stands for "explore and equip" - make sure the learning experiences you offer allow them to explore the essential questions, and equip them through coaching and teaching to succeed at final performances. R stands for "reflect and rethink" - provide experiences that make your students rethink what they know and refine their work along the way. E stands for "exhibit and evaluate" - use performances and products that reveal to you and your students what they understand and what remains to be learned.

W: How will you help students know where they are headed and why?

By reading the story book *I Want to Be* by Thylia Moss, teachers can set the stage for asking students to think deeply about who they are and what they might become.

H: How will you hook the students through engaging and thought provoking problems that point to the big ideas?

By reading the book *The Solar System* by Daniel Postgate, hook students into thinking about life on another planet.

E: What learning experiences will engage students in exploring the big ideas? What instruction is needed to equip students for the performance task?

Engage students in learning about their own bodies and their senses. Engage parents by asking them to help their child discover the similarities and differences between adults and offspring: size, shape, etc. Equip them with the necessary skills to create works of literature, art, movement, drama, and music by teaching them how to draw; how to handle paint and brushes; how to write and play simple rhythmic notation; how to do simple dance movements, how to form letters, words and sentences; how to use simple hand signals to communicate nonverbally. Provide current, accurate materials about Mars and planetary exploration.

R: How will you cause students to reflect and rethink to dig deeper into core ideas? How will they be guided to revise and refine their work?

Use journal activities to reflect on key ideas and issues; interview and question students to guide revision. Partner with parents to enlist their help in asking students what they know about Mars, humans, and life around them. Use writer's workshop conferencing to provide feedback for revision prior to publishing a book about The Earth, My Home, or Mars, a New Home.

E: How will students exhibit their understanding through final performances and products? How will you guide them in self-evaluation to identify strengths and weaknesses and set future goals?

Display their work (big book or individual student books) in the library, perform for peers (play their music, perform their dance or play), and exhibit artwork in school library or local art gallery. Interview to guide self-evaluation as students self-assess their work.

Using the Materials With Different Time Frames

Teachers may decide to spend varying amounts of time on these materials with their students. Here are some suggestions.

If you only have a week:

Choose one of the following:
* Because there is a need for more primary literature on the subject of space exploration, your class has been invited to write two big books for a major children's book club. Read grade level appropriate material on space exploration. Create one big book to portray a trip to Mars with accurate yet age appropriate language.

* What do you take with you to keep from getting homesick if you spend the night away from home? Read *Ira Sleeps Over* by Bernard Waber. What should the Mars pioneers take along to keep them from getting homesick? Ask parents to assist students in packing a backpack with items they would need. Share these in class and create writings to explain the contents in a display for the school or local community.

If you only have a month:

Choose one or two of the performance tasks that naturally fit your own curriculum. It may be that you are studying animals - create the food chain and Marsarium. Or you may be studying the body – create a dance based on how the body moves on Earth as compared to Mars. You may be studying community helpers - design and create a building for the Mars base. You may want to develop a mural for the center of the Mars base. What would it contain and why? Select the appropriate instructional activities that support those tasks and complete them.

If you have a year:

Expand the natural curriculum for your grade. Infuse the ideas from these units into your own curriculum. During a life science unit incorporate the the food chain, the Marsarium and dance. Look at the structure of plants and animals and consider what might live on Mars. Further study the similarities of offspring and parents. Investigate the geographic and cultural origins of the student's own families. Consider how humans have created oases from desert, such as in the western states. Tend a compost pile to observe the changes in matter over time. Create a simple constitution from the set of rules you developed. Expand the study of art, music, dance, and theater. Express the human spirit in a myriad of ways and art forms.

Unit Title: Journeys
Grade Level: K-2
Subject: Interdisciplinary
Time Frame: 8 weeks

Brief Summary of the Unit:

In this unit, students will examine the possibilities inherent in journeying to and creating a community on Mars. They will identify aspects of both their personal and regional communities necessary to the creation of a successful, new community elsewhere. As historical researchers, they will investigate the journeys of others uncovering similarities and differences in experiences and attitudes. They will study scientific documentation of space facts, with special focus on Mars, helping them to form a basic understanding of our galaxy and the universe. Through fictional characters, students will experience a journey to Mars, providing guided opportunities to make choices, interpret concrete data, exhibit awareness of the arts as a form of expression, and demonstrate an understanding of the concept of community. They will design and create a classroom-sized replication of this journey and will act as guides, leading other members of their family, school and regional communities through their journey to Mars.

Links to National Content Standards:

Science- Understands essential ideas about the composition of the universe
Language Arts- Gathers and understands information by reading, listening, writing, and viewing
Art- Understands characteristics of own and others artwork
Music- Sings alone and with others
Geography- Understands the patterns of human settlement and their causes
History- Understands the causes and nature of movements of people into and within the U.S.
Dance - Uses movement to communicate.

As a result of this unit, students will understand:
✧ Journeys expand our understanding of ourselves and our place in the world/universal community.
✧Our journeys both influence and are influenced by our beliefs, culture and circumstances.
✧ The stories we tell about our journeys impact the journeys of others.
✧ Journeys, imaginary or real, help us understand who we are and what we want to become.
✧ Where you come from and the journeys you take lead to where you are.

Students will know:
✧ Parts of our solar system/relationship between sun and moon
✧ Similarities and differences between Earth and Mars

- Key reasons for people to embark on journeys
- Simple design and composition in art, music, theater and dance

Students will be able to:

- Create a poem, picture, dance, drama, or adapt a song to communicate emotion, understanding and/or questions.
- Differentiate between levels of importance (pick five things to take with you to Mars; identify the two most important buildings in your community). Justify choices
- Create a display portraying the stages of a journey to Mars
- Communicate their learning to others, verbally and nonverbally

Essential questions guiding the unit:

- Why go?
- Are all journeys the same?
- Can journeys be shared?
- What choices would you and your family make about what to take with you to a new home?
- How would a journey to Mars be like that of the Pilgrims, the settlers of the Jamestown Colony or others who travel to live in a new land?
- How do you communicate to others about your journey?

Student assessments in the unit:

1. Draw pictures correctly incorporating moon and sun.
2. Use stickers or other manipulatives to create a sequenced model of our solar system.
3. Illustrate/write responses to prompts about various journeys.
4. Draw a map of the surface of Mars.
5. Write journal entries probing essential questions.
6. Create an audio/videotape of original poems, songs, dances, stories.
7. Create a three-dimensional representation of a journey to Mars which includes decisions about what to bring and leave behind, as well as a replica of the community created.
8. Teach peers, parents, community members about the journey to Mars by acting as guides through the replication of the journey.

Unit teaching and learning experiences:

1.Class discussion: Where have you gone? Activity: Have students bring photos, postcards, souvenirs, draw pictures, write descriptions about a place they've been. Those who haven't traveled can use local points of interest, or the class can take a trip to a local point of interest. Each student has a display area in which to organize their artifacts.

* Have students present their collection, explain where they've been and why they chose the pieces they did to represent their trip.

* Lead a class discussion: What is a "journey"? How would you get ready for a journey? What makes a journey different from a trip? a vacation?

2.Class discussion: You're going on a trip. What will you bring? How did you decide? Activity: Divide the class into small groups or pairs. Ask some groups one of the following questions and some the other. Compare and discuss answers. "You're going on a trip to the North Pole. What will you bring? How did you decide?" - OR - "You're going on a trip to a desert. What will you bring? How did you decide?" How would you change what you were bringing if you knew that your trip would last two days? two weeks? two months? two years? ten years? What if you could only take what would fit in this backpack? That night, students interview their families using the same questions. Create charts/graphs generated from the data collected.

3. Why Do People Take Journeys? - Read *Grandfather's Journey*. Have students learn about people and groups who take journeys by traveling themselves, around the room, to various theme-based centers. One center could be a Columbus exploration site, another Pilgrims and the Mayflower journey, while still others revolve around immigrants, Native Americans, Polynesian voyagers, sea and space exploration. At each center, students investigate questions. Who made the journey? Why did they go? What did they bring from home? What did they leave behind? How did they travel? What was the trip like? What did they expect or hope to find when they arrived? How was it different or the same as where they came from? What did they do to make it feel like home? Findings can be documented through illustrations and/or descriptions. Class discussion: What's the same about many journeys?

4. What's Going On Out There? - Read *The Magic School Bus Lost in the Solar System*. Have students watch a video (*Planets of the Sun* and *The Universe - Flight to the Stars*), examine maps of Mars and "research" Mars facts (research is guided: teacher pre-selects and organizes age appropriate, non-fiction, electronic and/or multimedia resources). Have students draw pictures to show Earth's sky at night and during the day and use stickers and/or models of planets to show order from the sun. With movement, show how the planets revolve around the sun.

5. Combine previous work in a class discussion "Can we get to Mars?" and "How might a journey to Mars be like the journeys of Columbus, the Pilgrims, Polynesian voyagers, immigrants, etc.?" Contact the Millennium Trails Program, United States Department of Transportation, 400 Seventh Street, SW, Washington, D.C. 20590 for information on the connection between physical trails, history and culture in your area. Have students use movement to show how actual journeys were made (across water in large or small vessels, on a trail,etc.). Then have students use movement to design different modes of traveling they will use on their trip to Mars (spin, run, jump, hop, leap, fly, etc.). Put their movement ideas into a simple dance structure.

6. In groups: Design a spaceship that could travel to Mars (think about size, speed, fuel, etc.); Draw a map of your route. How far will you travel? How fast will you go? How long will it take? Draw pictures of the trip as it would look through the spaceship window (take off, halfway there, landing on Mars). Move as though inside a spaceship versus outside the ship. How are the movements different?

7. Read "Destination Mars" (below). Create a "Destination Mars" journal for each student. Have students respond to writing/drawing prompts in their journals.

Destination Mars:
Part I: The year is 2030. Rob and Dina are brother and sister. Rob is six and Dina is seven. They love to travel, and they take trips with their family every year. This year, Rob and Dina are

taking a long trip. Their family is making a journey to the planet Mars. They're moving with other people from Earth to help start a new community. Discussion: Why might people from Earth want to leave and move to Mars?

Part II: The spaceship will be crowded, so the travelers must pack carefully. The grown-ups will pack the family's clothes. Rob and Dina may each pick five special things from their home on Earth to bring to their new home on Mars, but they must fit inside a backpack. It's hard to decide! Prompt: Help Rob and Dina choose their five special things. With a grown up at home, pack five things into a backpack for Rob or Dina. Have students bring backpacks to school the next day and explain why they chose the items included. Journal Entry: What's really important? Why?

Part III: Rob and Dina want to be sure that their Mars community is as good as the one they live in on Earth. They talk about which buildings are the most important in their community, but they can't agree. Each of them has two buildings that they think every community needs. Prompt: In your "Destination Mars Journal," draw pictures of the two buildings that you think Rob wants to include on Mars and the two that Dina thinks should be included. When you finish your drawings, tell why each building is important to a community.

Part IV: It's time to leave. Rob and Dina say goodbye and get into the spaceship with the rest of the travelers. Prompt: Pretend that you are either Rob or Dina. In your journal, write about what you will miss most. Then, write about what you think will be the most exciting part of this adventure. Have students write (or dictate) in their "Destination Mars Journal." Entries are signed, "Rob" or "Dina"

Part V: It's a long trip, and there's very little room to move around in the spaceship. Rob and Dina quickly see that they need to invent ways to enjoy the time. Grown ups teach them songs from home. They learn "O Susannah!," "She'll be Comin' 'Round the Mountain," and "America the Beautiful." Then, they make up their own songs and stories, draw pictures, write poems and think up games to play. They even invent new space dances. The captain of the spaceship gives them permission to use the ship's tape recorder and video camera to record their songs, stories and dances so they can be enjoyed over and over. Their pictures decorate the inside of the spaceship, and all of the travelers try playing the games that Rob and Dina invent. Have students listen to and sing above-mentioned (or comparable) songs. Prompt: Pretend that you are Rob or Dina. Make up a song, story or dance and record it. Draw pictures like the ones Rob and Dina drew on the spaceship. Write a poem or create a dance about leaving your home or about traveling, adventure or exploring. Invent a game that could be played in space. Share what you've done with a classroom partner and also with an adult at home.

Part VI: Finally, the spaceship lands. Rob and Dina can't wait to go exploring, but they need special clothes and equipment to survive the atmosphere on Mars. When they finally are able to leave the spaceship, what do they see? What is their new land like? Think about how a Martian might feel seeing the spaceship. Prompt: In your "Destination Mars Journal," draw a picture of Rob and Dina leaving the spaceship and standing on Mars for the first time. Then, draw the Martian who sees them and write what he's thinking.

Part VII: All of the people on the Mars journey need places to live. Houses are built. What would Rob and Dina's house look like? How might the rooms inside look? Prompt: In your "Destination Mars Journal," write a description or draw a picture of the outside of Rob and Dina's Mars house. With a partner, draw a picture of one of the rooms inside the house. Write the name of the room at the bottom of the picture.

Part VIII: It's time to build the rest of the new community. Prompt: Look back in your "Destination Mars Journal." Find the buildings that Rob and Dina thought were the most important to their community on Earth. Share those with a small group of classmates. Which ones did you all pick? Which one did someone else pick that you didn't, but now you think is important, too? Talk with your whole class and decide what buildings this new Mars community must have. Together, describe what each building should look like. As a result of the class discussion, the teacher will make a poster-sized chart of the buildings and descriptions.

Part IX: People who live in this new Mars community still have friends and relatives back on Earth. They want to keep in touch with them and let them know about their journey and new life. The Captain is returning to Earth and will bring with him any messages or souvenirs that people want to send, as long as they are clearly marked and will fit inside a backpack. Prompt: With whom might Rob and Dina want to communicate? What would they put in their backpacks? Share your ideas with a partner. Write or draw in your journal, showing what Rob and Dina could send to Earth. Explain to whom they would send each thing and why. At home, ask a grown up to help you pack a backpack for Rob or Dina to send back to Earth. Label each thing with the name of the person it's for (example - For: Martha Greene, grandma).

Part X: The ship will make a return flight to Mars in three years. Think about what Rob and Dina might need or want Grandma to pack in the back pack for them. Write or draw in your journal, showing Rob and Dina using the five things Grandma packed.

8. How do We Share the Journey? - Poll your students about how people communicate their ideas, feelings and experiences. Incorporating written, oral and artistic modes of communication, students are guided in the creation of a three-dimensional display communicating the journey of Rob and Dina. The classroom (or some other designated space) can be transformed into the display by separating it into linked areas, with groups of students responsible for their development. The first space, Earth, could contain the backpacks with the items that Rob and Dina took with them. In the next area, could be displays of the spaceships, maps and information generated by the students' preliminary guided research. Following this might be a representation of the inside of the spaceship, including the pictures that were drawn, recordings of students' songs, poems, stories and dances, and examples of invented games. The windows of the spaceship might show scenes from the takeoff, trip and landing. Next, comes the Martian landscape, as it originally appeared to Rob and Dina. In the adjoining space could be a representation of the new house on Mars, and past that, a model of the new community, incorporating the "most important buildings" identified by the students. Finally, the display could end as it began, with backpacks, this time full of things being sent home. Each display segment draws from the students' activities during the unit.

9. Once the display is complete, the students act as guides, leading members of their community (school, home, town) through the journey, sharing their knowledge and understanding. Before the big day, rehearsals using classmates as tourists can provide opportunities for feedback and

revision. At the end of the tour, participants and guides alike are invited to ponder whether this is "the end," discussing possible future journeys for Rob and Dina or identifying a journey that they themselves would be interested in making.

10. Return to a discussion of the unit essential questions and where future journeys might lead.

More Ideas for Teachers to Consider

W: How will you help students know where they are headed and why?

By reading the book *The Magic School Bus Lost in the Solar System*, you can introduce students to both the solar system and the idea of space travel. This book presents facts in an interesting, non-threatening manner and models an inquiry-based approach.

H: How will you hook the students through engaging and thought provoking problems that point to the big ideas?

By beginning with a trip that students have taken, travel becomes personal and accessible. Investigating the journeys of others, asking why they went, what they took with them, what they left behind, and what their journeys have in common widens the lens of journeys and helps begin the move from concrete to abstract thinking. The story *Destination Mars* allows students to make choices and decisions and examine their own values by identifying with the journey of other children.

E: What learning experiences will engage students in exploring the big ideas? What instruction is needed to equip students for the performance task?

Engage students in investigating the solar system, Mars and the journeys of others. Engage parents by asking them to help students make selections to communicate what they value most and also by asking them to participate in interviews. Equip students with the necessary skills to create works of literature, art, theater and music by exposing them to real world models of such, and by teaching them how to draw, how to handle paint and brushes, how to write and sing simple songs, how to perform simple dances and dramas, how to form words and sentences, how to work individually and in cooperative groups.

R: How will you cause students to reflect and rethink to dig deeper into core ideas? How will they be guided to revise and refine their work?

Use journal activities and guiding questions to encourage reflection, both written and oral, on key ideas and issues. Use peer and teacher interviews, conferences and feedback sessions to guide revision.

E: How will students exhibit their understanding through final performances and products? How will you guide them in self-evaluation to identify strengths and weaknesses and set future goals?

Display or demonstrate their work (art, literature, music, drama and dance), incorporating it into the creation of a three-dimensional display of the journey to Mars. Enlist the students as guides, putting them in the position of leading groups of peers, parents and community members through the display and teaching them about the journey. Interview and provide rubrics and checklists to guide self-evaluation as students self-assess their work.

Using the Materials With Different Time Frames

If you have a week...allow for extended time during each day.

1. Introduce essential questions. Read the story *Grandfather's Journey* and a story about Columbus. Small group discussion: What is a journey? How is it different from a vacation? Why did Columbus and Grandfather make their journeys? What was hard about leaving their homes? What did they take with them? What did they leave behind? How did they made those choices? Groups report out in full class discussion. Journal entry: What's the same about the journeys people make? If you were going on a journey and could pack only five things in your backpack, what would you bring? Why? Ask a grown up at home the same questions, and discuss them the next day.

2. Read *The Magic School Bus Lost in the Solar System.* Discuss Earth, moon and sun and how they are related. Students draw pictures showing when the sun would be shining and when we would see the moon. Explain they'll be trying to find out as much as they can about Mars. Provide resources and an organizer to help them catalogue and categorize information found. Students, in pairs, use the information to help draw a space ship that could travel to Mars, plan a map of the route, and describe, in words or pictures, key moments (blast off, the midway point, Mars landing).

3. What parts of your Earth community would you include if you were designing a new community on Mars? Why? What parts would you leave out? Why? Draw a plan of this new community.

4. Have students select parts of each plan to be used to create a replica of their new community. Allot an area of the room (bulletin board, bookshelves, wall space, etc.) and, using teams of students working on designated sections, build a model of the Mars community.

5. Discussion: Who would live there? How would they survive? Describe a day in the life of someone who moves to Mars? If beings already lived there, what might they think about Earth people coming in and building this community? Journal entry: What kinds of things might someone say or send to Earth to let people know what life on Mars is like?

If you have one month...

1. Introduce essential questions. Read the story *Grandfather's Journey* and a story about Columbus. Small group discussion: What is a journey? How is it different from a vacation? Why did Columbus and Grandfather make their journeys? What was hard about leaving their homes? What did they take with them? What did they leave behind? How did they made those choices? Groups report out in full class discussion. Journal entry: What's the same about the journeys people make? If you were going on a journey and could pack only five things in your backpack,

what would you bring? Why? Ask a grown up at home the same questions, and discuss them the next day.

2. Read *The Magic School Bus Lost in the Solar System*. Discuss Earth, moon and sun and how they are related. Students draw pictures showing when the sun would be shining and when we would see the moon. Explain they'll be trying to find out as much as they can about Mars. Provide resources and an organizer to help them catalogue and categorize information found. Students, in pairs, use the information to help draw a space ship that could travel to Mars, plan a map of the route, and describe, in words or pictures, key moments (blast off, the midway point, Mars landing). Use a rubric to guide self and peer assessment and revisions.

3. Teacher reads "Destination Mars" and students do related activities, referring to rubrics, checklists and lists of performance criteria as they edit and revise their various products.

4. What parts of your Earth community would you include in a new community on Mars? Why? What parts would you leave out? Why? Draw a plan of this new community.

5. Students select parts of each plan to be used to create a replica of their new community. Allot an area of the room and, using teams of students working on sections, build a model of the Mars community.

6. Journal: Who would live there? How? Describe a day in their life. What might Martians think about Earth people building this community? What might someone say or send to Earth to let people know about life on Mars?

If you have a year:

1. Follow original design, giving extra time for added exposure to the concepts of poetry, songs, art, dance, and drama.

2. Share more literature revolving around themes of journeys and community.

3. Keep a diary as a Mars pioneer observing all of the changes to his/her planet.

4. Have students design a national anthem, seal, and constitution for their Mars community.

5. Go into more detail of social, economic and government design on Earth and in the new community.

6. Maintain "Journeys" and "Building Community" as big ideas that drive your year. Incorporate it within the state or district curriculum for your grade.

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Professional Resources for the Teacher

These materials were developed by writing teams using the *Understanding by Design* framework. The framework is a series of tools and templates that lead educators through a backwards design process for writing curriculum and assessment that leads to student understanding. Published by the Association for Supervision and Curriculum Development (ASCD), the framework is explained in a book, a short videotape, and soon in a CD-ROM and Designer's Handbook. Workshops are planned in various cities, and a cadre of trainers are available to bring the Understanding by Design training to your site. For more information, call 1-800-933-2723 then press 2. Or visit our website at **www.ascd.org.**

Other sources for teacher professional development in curriculum, assessment, the arts, sciences, and technology available through ASCD:

1) Interdisciplinary Curriculum: Design and Implementation
   Heidi Hayes Jacobs, ed.
   Explains the two important criteria every interdisciplinary program must adhere to.
   Presents six design options for an interdisciplinary curriculum and a useful process for

integrating the teaching of science, math, language arts, social studies, and the arts. Plus two successful case studies of interdisciplinary programs.

2) A Comprehensive Guide to Designing Standards-Based Districts, Schools, and Classrooms
Robert J. Marzano and John S. Kendall
This book is an invaluable resource for districts, schools, or individual teachers who wish to organize curriculum, instruction, and assessment around standards. It is based on the Mid-continent Regional Educational Laboratory's (McREL) work with scores of districts, hundreds of schools, and thousands of teachers. The book deals with basic questions such as these: Who will be involved in setting standards? What types of standards will we have? At what grade levels will they be written? Who will be held accountable and what will they be held accountable for? How will students be assessed on standards? How will students' progress on standards be reported? To help answer these questions, sample report cards, teacher grade books, performance assessment tasks, rubrics, and national efforts to design and implement samples are provided. This book asks and answers all important questions in enough detail to allow any district, school, or individual teacher to fully design and implement a standards-based system. 1996 ASCD/McREL book developed by McREL.

3) Design Tools for the Internet-Supported Classroom
Judi Harris
Judi Harris offers staff development professionals an important resource for helping educators create powerful, curriculum-based online activities. Drawing on research and extensive online experience, she demonstrates how teachers can best become designers for Internet projects. She shares 18 structures for successful telecomputing activities, an 8-step process for creating those activities, 5 purposes for students' teleresearch, and 10 types of Web pages teachers can use to support their projects. Harris also discusses which educators are likely to adopt an innovation first--and last--as well as how to work with them and what types of staff development to offer. She also provides numerous online resources and examples of successful, classroom-tested projects.

4) Design as a Catalyst for Learning
Meredith Davis, Peter Hawley, Bernard McMullan, and Gertrude Spilka
Involving students in active learning experiences is much easier and more rewarding when you teach them the skills and processes that professional designers--architects, graphic artists, and others--use every day. This ground-breaking book introduces you to the 7 steps in the design process and describes effective design activities and strategies for every grade level and subject area. Learn how the design process naturally integrates subjects, helps you teach thinking and communications skills, and encourages students to apply academic concepts in authentic tasks. Explore many examples of exciting design activities, including: * A 4th grade class where social and environmental studies come alive for students while they design and build Native American housing * A 7th and 8th grade class where students apply knowledge of math and science through a critique of environmentally unsound packaging * A high school physics class where students learn fundamental principles as they design their own Rube Goldberg projects

5) A Teacher's Guide to Performance-Based Learning and Assessment
Educators in Connecticut's Pomperaug Regional School District 15
This book is for classroom teachers across the spectrum of grade levels and disciplines who want to learn strategies for creating and using performance-based learning and assessment. The audience will also include educators responsible for leading and managing long-term change to improve student performance.

6) Developing Performance Assessments
One 55-minute video program and a Facilitator's Guide explain and show how to use the four major components of the process of developing performance assessments. The four components are: Selecting the learning goals/objectives/content standards, Designing the task, Determining how to evaluate the task, Reviewing and revising the task and scoring tools. The program shows actual examples of task design sessions, classroom implementation of the task, and task revision sessions. Examples are drawn from elementary, middle school and high school classrooms engaged in science, language arts, and math lessons. Featured experts Grant Wiggins and Jay McTighe explain concepts and practices. The 88-page Facilitators Guide includes outlines for a 1.5-hour workshop and a 4-hour workshop that leads participants through the entire development process and teaches them how to develop their own performance assessments. The Facilitator's Guide also contains handouts, overheads, and background readings.

7) Mapping the Big Picture: Integrating Curriculum and Assessment K-12
Heidi Hayes Jacobs
Teachers have always used the school calendar to plan instruction. Now, using a standard computer word-processing program, they can collect real-time information about what is actually taught to create "curriculum maps." These maps provide a clear picture of what is happening in their classes at specific points during the school year. The benefits of this kind of mapping are obvious for integrating curriculum: when curriculum maps are developed for every grade level, educators see not only the details of each map, but also the "big picture" for that school or district. They can see where subjects already come together--and where they don't, but probably should. In Mapping the Big Picture, Heidi Hayes Jacobs describes a seven-step process for creating and working with curriculum maps, from data collection to ongoing curriculum review. She discusses the importance of asking "essential questions" and of designing assessments that reflect what teachers know about the students in their care. She also offers a viable alternative to the "curriculum committees" that are part of almost every school district in the United States. The book concludes with more than 20 sample curriculum maps from real schools, all of which were developed using the process described in this book.

8) Whelmers: 41 Awesome Easy-To-Do Science Activities
This easy-to-use CD-ROM contains full-motion video demonstrating 41 classroom science activities that will intrigue students ("whelm" them, not "overwhelm" them) and help teachers introduce basic principles of air pressure, chemistry, energy, density, and waves. Science background information explaining the concepts, process skills, teacher tips, materials lists, safety measures, and correlations with assessment and specific national standards (NRC) for grades K-4, 5-8, and 9-12 are included. Each hands-on

activity uses everyday materials available in grocery and hardware stores. Expert science teacher Steve Jacobs, of the Jake's Attic television series, demonstrates the experiments with students in a friendly, engaging manner. Software application included: QuickTime.

9) ASCD Topic Pack -- Arts Education
This Topic Pack includes numerous full-text articles on arts education, carefully chosen from "Educational Leadership," "Education Update," and other ASCD publications; a list of ASCD resources on arts education, including books, videotapes, and audiotapes, with brief descriptions; ERIC digest summaries and a list of ERIC documents on arts education, along with information on how to obtain articles from ERIC; a bibliography of journal articles on arts education; and a list of selected Internet resources on arts education.

10) Make It Happen! Inquiry and Technology in the Middle School Curriculum
Judith Zorfass, Educational Development Center, Newton, MA
A print, video and software package to aid technology integration for constructivist, interdisciplinary middle school classrooms. Make It Happen! is a tool for middle school teachers to guide students through research within thematic curriculum units. This constructivist tool helps teachers and students focus research questions, develop a plan for gathering information, integrate and synthesize the information, prepare findings for presentation. The targeted audience for this product is middle school teachers, parents, technology coordinators, and others involved in guiding student research. Materials in the Make It Happen! package include: A Facilitator's Manual - with guidelines, handouts, agendas, discussion topics, etc. (3-ring binder, 242 pages), A Teacher's Guide - presents a model unit and tips for curriculum design, An Overview Video - 47 minute video with 4 vignettes from actual middle school classrooms using Make It Happen!, Search Organizer Software - Software for student use to generate research question, plan research, record and analyze information and create draft report. Includes a site license for 150 simultaneous users, (MACINTOSH format ONLY/System 7.1 or higher), a 46-page User's Manual, and a 10-minute demonstration video on how to use the software.

11) Planning Integrated Units: A Concept-Based Approach
This video-based staff development program includes a 65-minute videotape and an 84-page facilitator's guide. Planning Integrated Units examines how to design integrated units that not only help students see connections among different subject areas but also challenge students to think at higher levels and promote a deeper understanding of what they're studying. The program begins by explaining the concept-based approach. Through lessons in elementary and middle school classes, teachers demonstrate how to use concepts to view topics and focus students on the essential understandings, or big ideas, that students can transfer to other learning situations. Curriculum expert Lynn Erickson explains how framing units around concepts and essential understandings enhances student understanding and is compatible with how people actually learn and apply knowledge. A major portion of the program focuses on how to plan a concept-based integrated unit, using an 8-step process developed by Erickson. Choose a theme that easily incorporates a variety of subjects. Identify a concept for viewing the theme. Select topics from

your curricula for literature, math, science, and other subjects that reflect the theme and concept. Identify essential understandings -- the big ideas related to the theme and concept. Develop guiding questions that will help students grasp the essential understandings. Determine the complex performances and key skills you want students to learn during the unit. Design the culminating performance task that will enable students to demonstrate what they know, understand, and can do as a result of the unit. Write instructional activities that will engage students in learning the essential understandings and key skills.

Designed by Hilarie Davis, Nancy Ross, Lawrence Crum, and Robert Myers

Introduction

As long as we have been able to see the stars in the night sky we have reached out with our imaginations, wondering what it would be like to be there - looking backing at our blue green planet. In this century we have reached into those night sky dreams with real explorations - a walk on the moon, a live-aboard spaceship and pictures of Mars from its surface! Maybe that's how it always begins, minds creating images of what might be, imagination creating reality.

Now as we approach a new millennium, imaginations have been stirred again by the real possibility of humans living on Mars. The excitement of space travel and Mars gives us a rare chance to simultaneously imagine the future and honor the past. The educational materials in this package use the lenses of art, science and community to invite teachers to engage their students in thinking about the quality of life in their existing communities and in a community they design for Mars for the year 2030.

We hope these materials will provide ideas and resources for teachers with different purposes and timelines. Some of the learning experiences will dovetail with curriculum goals, while others will integrate or go beyond the content knowledge. The materials support students in addressing the questions: What makes life meaningful for individuals and communities? What do we need for survival? While all the materials are designed to complement each other and extend over the course of a year, the time management section offers suggestions for how to dip into materials for a week or a month. Many of the activities lend themselves to parent and community involvement as students struggle with the issue of what is really important to them and to their communities.

The two units are designed for understanding the concepts of home and community and the structures which support them. They are built on standards, performance, and results and encourage the construction of knowledge by students. The Habitat Alternatives activity uses a Problem Based Learning (PBL) approach to engage students in groups to explore viable options to the challenge of living on Mars. Problem-based learning features a carefully designed open-ended problem that gives students just enough information to guide an investigation.

Notes for the Teacher

In these materials, students study our life on Earth to consider how to have a safe, meaningful and creative community life on Mars. What physical requirements are third, fourth and fifth graders aware of? What do they need, want and use every day? What would they expect to take with them given the inhospitable environment on Mars? Students are asked to think about the aesthetic and social necessities of life in preparation for creating a community on Mars, as well as the physical requirements for survival. How do people create meaning in their lives and how do the spaces and structures around them support that meaning-making?

First, students explore the theme of home in the unit Home is Where the Heart Is, through exploring and describing their own homes - their rooms, residences, and communities. What makes a home a home? What makes us feel "at home?" How do our homes reflect our needs and desires? Through a variety of "observation" activities, students gain skill in noticing, describing and representing their physical space and what it means to them. These activities are designed to develop student skill in observation, description, definition, comparing and representing, and to build knowledge about the importance of "home," the physical characteristics of familiar places, the ways to characterize them, the interdependence among people and the meaning we attach to objects, ideas and experiences. By engaging all the senses, student imagination about home is invoked, laying the groundwork for them to create (in the PBL unit) a community yet to be imagined on Mars - a community of sensing and feeling, interdependent individuals in a safe, sustainable habitat.

In the unit on structures, Survival of the Fittest, students study the lifestyles of people on Earth who live in Mars-like conditions -scientists in Antarctica (dry desert) and Inuit in the arctic circle (cold temperatures, scarce resources), desert dwellers (dust/sand storms, open terrain) - to discover how they survive and make their lives meaningful. These activities are designed to develop student knowledge and skill in understanding and describing social and physical systems, adaptation, and structures which contribute to a quality life. How do people live in inhospitable conditions? How does their art come out of and play a role in their lives? How do they relate to each other and to the outside world?

In the Problem-Based Learning unit, Habitat Alternatives: Seeing Red, students become habitat experts to market Mars or Earth to people who wish to relocate. These activities are designed to develop student knowledge about Mars as compared with Earth and present factual information and decision-making support for a specific audience. What do people need to know in order to choose a home? How do they make a choice? How can you support their decision-making with information? In order to create the Mars relocation materials, students will describe how people could live in a Mars habitat. For the Earth materials, they will investigate and characterize how human requirements for community, meaning and survival are met here on Earth.

The Units

In each of the following units, the "Understanding By Design" elements are presented. Overarching questions and essential questions are the global ideas that are only partially addressed in this unit, and may be revisited through many units throughout a students' school experience. Unit understandings and Guiding questions identify the more specific focus of the unit. The Knowledge, Skills and Standards are followed by a variety of assessment suggestions. The Learning Activities outline the flow of the unit from engaging the students with the ideas to the development of those ideas, making connections, asking questions, building relationships and presenting their ideas. Resource materials follow each unit, and a bibliography for all the learning activities appears at the end of the packet.

Additional ideas and resources:
As whole class activities, you might be able to use some parts of the computer simulations - Sim Earth and Sim City.
Larsson, Carl and Rudstrom, Lennart (1974). A Home. NY: G.P. Putnam's Sons.
Lovelock, J. (1987). Gaia: A New Look at Life on Earth. Oxford Univ Press; ISBN: 0192860305
Potter, R.R. and Gallin, R. (eds.) (1990). Buckminster Fuller (Pioneers in Change Series). Silver Burdett Press; ISBN: 0382099672

Unit Title: Home is Where the Heart Is
Subjects: Art, Science, Humanities
Grades Level: 3-5
Timeframe: 8 weeks

Link to National Content Standards (Taken from *Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education*, McRel/ASCD, http://www.mcrel.org)

- **Art**- Understands connections among the various art forms and other disciplines.
- **Visual Arts**- Understands and applies media, techniques and processes related to the visual arts. Knows how to use the structures and functions of art.
- **Dance** - Understands the role of dance in our culture and around the world.
- **Social Studies**- Understands the role of diversity in American life and the importance of shared values, political beliefs, and civic beliefs.
- **Communication**- Gathers information effectively through reading, listening and viewing. Gathers and uses information for research purposes.
- **Science**- Knows that people have always had questions about their world; science is one way of answering questions and explaining the natural world. Knows that things have properties that can be used to tell them apart and to find out which of them are alike. Knows how an object's properties can be measured using tools.
- **Geography**- Understands the physical and human characteristics of place.
- **Math** - Constructs physical representations of complex problems. Uses graphic representations. Understands that scale drawings can be used to represent shapes. Understands that area can be thought of as a collection of unit squares. Understands the basic concept of three dimensions.

Brief Summary of Unit:

Students will explore the theme of home in the unit, through exploring and describing their own homes - their rooms, residences, and communities. What makes a home a home? What makes us feel "at home?" How do our homes reflect our needs and desires? Through a variety of observation activities, students gain skill in noticing, describing and representing their physical space and what it means to them. These activities are designed to develop student skill in observation, description, definition, comparing and representing, and to build knowledge about the importance of "home," the physical characteristics of familiar places, the ways to characterize them, the interdependence among people and the meaning we attach to objects, ideas and experiences. By engaging all the senses, student imagination about home is invoked, laying the groundwork for them to create (in the Problem-based Learning unit) a community yet to be imagined on Mars - a community of sensing and feeling, interdependent individuals in a safe, sustainable habitat.

As a result of this unit, students will understand:

✧ A meaningful life requires physical safety, emotional and creative satisfaction and social interaction.
✧ Our homes contribute support to our individual needs and wants.

✧ Our communities contribute support to our individual and mutual needs and wants.
✧ We can maintain and improve our quality of life by taking multiple perspectives, interpreting what we perceive and communicating our understandings to others.
✧ The uniqueness of our communities are expressed in art forms.

Students will know:

✧ Basic needs are common to everyone, physical needs such as air, water, protection from extreme temperatures, food and shelter, social needs such as communication and companionship, emotional needs such as self- expression and understanding and aesthetic needs such as beauty and variety.
✧ A home is a place we identify with, that provides comfort and safety, that we contribute to and that supports our self expression and interdependence (room, residence, geographic and social community, state, nation, world).

Students will be able to:

✧ See the spaces we live in and create (quantitatively, qualitatively)
✧ Represent the meaning they have to us through artistic expression
✧ Prioritize and choose what is important

Essential questions guiding this unit:

✧ What basic physical needs must be met to survive?
✧ What brings emotional satisfaction and meaning to an individual?
✧ How does social interaction help us to make meaning?
✧ How does art reflect culture?
✧ How does your environment help you to meet your basic needs and wants?
✧ What do you need to have a good life - physically, emotionally, mentally and socially?
✧ What is unique about my culture? what is universal?

Students assessments in the unit:

1. Home is Where the Heart Is - Students represent their "home" from at least 3 perspectives in at least 3 art media.
2. Journey Response -Students identify their individual and mutual needs and wants that can be transported in two shoeboxes, their heads and their hearts.
3. The Bottom Line - Students negotiate their most important personal and community, tangible and intangible possessions that meet their basic needs in a town meeting.
4. Quiz: Basic physical needs for survival (how much oxygen, calories from food, protection against extreme heat and cold. . .)
5. Prompt: After studying artists' portrayal of home, create/represent your own ideal self-expressive space.
6. Prompt: On a map of the area, identify the personal, social and physical needs and wants met by your community.
7. Student self-assessment: How well do I understand what my needs and wants are? How do I take responsibility for getting my needs and wants met?

Teaching and learning experiences in the unit:

1. What is a home?

Look at ways artists from around the world have portrayed homes or living spaces (a red day for Matisse's red studio; a lunch modeled on Monet's table; a visit to Van Gogh's studio at Arles; Pierre Bonnard's dining room; a tour of Carl Larsson's home through the book, *A Home*; a musical visit to the Planets with Gustav Holz, Faith Ringgold's book *Tar Beach*, Mayan homes on ceramics, Indian miniatures depicting daily life).

2. How do you see your home?
Introduce different ways of seeing the properties of objects and ideas so students can portray their homes from different perspectives in different media and art forms (see list of Observation Activities below), including written descriptions, poetry, interviews with objects, games, line drawings to describe & show emotional qualities, floor plans, birdseye views, rubbings for texture and form, organizing by shape, symbolizing ideas, working with color to understand space and show emotion and using media such as pencils, paint, craypas, clay, cardboard, wood, wire, collage, found objects.

Observation Activities

- Discuss what you can discover about a room from looking at the objects, colors and textures.
- Describe your room in a letter to a friend.
- Make a diorama of your room using a shoebox.
- Make rubbings of two objects in your room.
- Make a floor plan to scale.
- Make a painting of your room and show through your choice of colors what you feel about your room.
- Do a drawing or painting that is a birdseye view of your room.
- Deconstruct your room and put it back together in a new way.
- Make a puzzle of your room that someone else can put together.
- Collect pictures of bedrooms from other cultures.
- Write a poem, story, song, dance and play about your room.
- Make of chart or a Venn diagram of the objects in your room by categories like color, importance, necessary, nice
- Do all the same things using just your bed or another object such as a dresser, closet or toy.
- Design a container to transport your object, to protect it, to keep it safe. Measure its dimensions and represent its surface area on a grid.
- Other things to investigate: food, family, pets, money, clothes, holidays.

3. How is our classroom a home?
Form study groups to observe, describe and represent the classroom from different perspectives - as a home for learning, as a physical space, as a common space.

4. What makes a home a home?
Study and represent your home space as a common space. Interview the people with whom you live about what is important to them about home. Collect samples of music you and your family listen to. Make a collage of bits of all of them. Compare to music samples that would come from your grandparents' homes.

5. What do we need to survive?
Identify your basic needs, how they are satisfied, draw them, find songs about them, write a letter

to your parents about them.

6. What are the most important elements of our home?
You are leaving on a long journey and can only take a few things. Read the Shoebox story (provided below). You can take two shoeboxes - one for needs, one for wants, and two magic boxes - your head (things you know, believe, tools like problem solving, skills like reading, image of home) and your heart (things you hear, hold, feel, trust, as well as songs, hopes, memories). What would be in your shoeboxes?

"The Shoebox"
"Picture an 11 year old child looking around his room, knowing he is about to leave on a journey, maybe for 5-10 years. What should he take? He made himself two shoeboxes. In one shoebox, he put pictures of his family, poetry he had written, a postcard from a girl, his treasure, an autobiography. And in the other box, he put an extra pair of shoes, some underwear, a hanky, a knife, a watch and a toothbrush. One day he came home from school and was told, 'It's time for us to go.' He grabbed one shoebox, and they left. When they stopped again, he looked into the shoebox and he had taken the wrong one. He had the hanky, the shoes and the watch."

7. What is most important about our home to our family?
Interview your parents/caregivers about what would they take? What intangibles such as songs, ideas, dances, stories, and poetry are on their lists? Return to needs list, revise and decide what to take. Do a survey of the most important items, then tally and graph.

8. What collective needs does the community meet? What individual needs? What would the members of the community take?
Study community space. Interview leaders such as mayor, clergy, about how they represent the community. Study representations of the community - maps, charters, mission, constitution. Revise personal box contents. Create class list from individual lists.

9. How do we as a community decide what to take?
Have a town meeting to decide what to take from the community. Play the different roles of people in the community who were interviewed or who you want to have a voice.

More Ideas for Teachers to Consider

The acronym WHERE is a way for teachers to think about their curriculum and instruction. W stands for "where" - make sure your students know where the teaching and learning experiences will take them, the goals of the unit and your expectations. H stands for "hook" - hook them with interesting experiences up front to get them excited about learning. E stands for "explore and equip" - make sure the learning experiences you offer allow them to explore the essential questions, and equip them through coaching and teaching to succeed at final performances. R stands for "reflect and rethink" - provide experiences that make your students rethink what they know and refine their work along the way. E stands for "exhibit and evaluate" - use performances and products that reveal to you and your students what they understand and what remains to be learned.

W: How will you help students know where they are headed and why?

By taking students on a tour of artists' homes, you begin to open their eyes to home as form of self-expression as well as survival. Explain that they will be able to create their own ideal self-expressive space, as a result of exploring their current home from many different perspectives.

H: How will you hook the students through engaging and thought provoking problems that point to the big ideas?

What does a room look like from above? from below? through a fish eye? in color terms? in texture terms? Start by asking students to observe and record their ideas about their rooms.

E: What learning experiences will engage students in exploring the big ideas? What instruction is needed to equip students for the performance task?

Create a gallery of student portrayals of their rooms. Introduce them to different perspectives and media such as poetry, interviews with objects, and line drawings to portray their own personal space. Have daily tours of the growing gallery. Encourage students to portray emotional and social aspects of their rooms through writing and visuals. Of all these things, what makes a place "home?" Ask students to reflect on this and then ask their families and make a collage of what they find out.

R: How will you cause students to reflect and rethink to dig deeper into core ideas? How will they be guided to revise and refine their work?

Engage students in learning about how their basic needs are met. Then ask them to pack for a long journey with only four boxes: a shoebox of needs; a shoebox of wants; a heart; and a mind. Involve parents and the community by having students interview them about what they would take.

E: How will students exhibit their understanding through final performances and products? How will you guide them in self-evaluation to identify strengths and weaknesses and set future goals?

Display their boxes in the classroom, the library or town hall. Hold a town meeting to discuss what to take from the whole community.

Unit title: Survival of the Fittest
Subject(s): Science, Art, Humanities
Grade Level: 3-5
Timeframe: 8 weeks

Links to National Content Standards (Taken from *Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education*, McRel/ASCD, http://www.mcrel.org)

- **History**- Understands the dreams and ideals that people from various groups have sought, some of the problems they have encountered in realizing their dreams, and the sources of strength and determination they drew upon and shared. Understands how people have helped make their communities better places to live.
- **Language Arts**- Asks and seeks to answer questions about the people and places in one's local community and regarding the characteristics of various places outside the local community and the people who live in those places. Actively contributes to group discussions.
- **Science**- Knows that people continue inventing new ways of doing things, solving problems, and getting work done. Knows that scientists develop explanations using observations and what they already know about the world.
- **Art**- Understands connections among the various art forms and other disciplines.
- **Visual Arts**- Knows a range of subject matter, symbols and potential ideas in the visual arts. Understands the visual arts in relation to history and culture.
- **Dance**- Understands dance in various cultures and historical periods. Understands connections between dance and healthful living.
- **Music**- Understands the relationship of music, history and culture.
- **Geography**- Understands that culture and experience influence people's perceptions of places and regions. Understands how physical systems affect human systems.
- Math - Constructs physical representations of complex problems. Understands that scale drawings can be used to represent shapes. Understands the basic concept of three dimensions. Collects and organizes simple data sets to answer questions.

Brief Summary of Unit:

Students will study the lifestyles of people on Earth who live in Mars-like conditions - scientists in Antarctica (dry desert) and Inuit in the arctic circle (cold temperatures, scarce resources), desert dwellers (dust/sand storms, open terrain) - to discover how they survive and make their lives meaningful. These activities are designed to develop student knowledge and skill in understanding and describing social and physical systems, adaptation, and structures which contribute to a quality life. How do people live in inhospitable conditions? How does their art come out of and play a role in their lives? How do they relate to each other and to the outside world?

As a result of this unit, students will understand:

✧ Structures are the core elements that support, protect and uphold ideas, organizations and buildings.
✧ The structure of our buildings, relationships, environment, beliefs and language affect our health, thinking, activities, and interactions.
✧ An understanding of structures helps us successfully adapt to different environments.

✧ Building structures and social structures are created around needs and wants.
✧ The arts are a reflection of a culture.

Students will know:
A structure shows the important elements of a system in relationship to each other, such as the supporting structure of a building like a geodesic dome, or a Bill of Rights as a structure for how people will treat each other.

• We can observe and analyze the environment to identify its structures.
• Structures are often repeated or reflected in each other and form patterns (fractals, mirror images, tessellations).

Students will be able to:
• Observe and question in order to identify key elements and relationships.
• Portray a structure through drawing, description or story.
• Use a known structure as the basis of constructing something new.

Essential questions guiding the unit:

✧How can physical structures be adapted to different environments to support survival?
✧How do members of a group structure their individual rights and responsibilities to each other?
✧How do our beliefs structure our thoughts and actions?
✧How does art reveal culture?
✧ How can the structure of your home be adapted to continue to meet your needs in a different physical environment?
✧ What social structures do people develop to survive together in inhospitable environments?
✧ How do people use the arts and design to define their place within the structure of social and physical environments?

Student assessments in the unit:

1. **Home Base:** Students sketch their homes and label the structural elements of the physical landscape, the building, the social rights and responsibilities and the aesthetic and emotional support.
2. **The Land of Oz:** Student teams design habitats for 3 different inhospitable environments.
3. **Home Again:** Student teams compete to re-inhabit their community using the lessons learned from a 100 day stay in an inhospitable environment.
4. Quiz: Environmental characteristics of the inhospitable environments.
5. Quiz: Characteristics of structures designed for different environments (geodesic domes, tents, igloos).

6. Prompt: Weekly diary entry from the 100 day stay in an inhospitable environment.
7. Student self-assessments: How do I adapt to change? take risks? create alternatives? What do I need and value most? What are the necessary and sufficient conditions for my emotional, social, physical and aesthetic survival?

Teaching and Learning activities in the unit:

1. What are essential structures in my community?
Recall the story of the Wizard of Oz and how Dorothy and her house were transported from Kansas to Oz. Now a catastrophic event is threatening your community (volcano, earthquake, nuclear accident) To be safe, you have received a TRANSPORT ORDER to move your community to an isolated area. You must move, but can take your house and 5 buildings that make up your social structure and provide for your needs. You will be in this new location for 100 days in groups of 100 people.

2. How does my home meet my needs?
Artists at work: Sketch or build a model of the structure of the building in which you live. Label the importance of the key elements of the structure in terms of how it provides for your needs in the local environment, such as a roof for protection from rain, living room for being with others, bedroom for privacy and sleeping, rugs for color and quiet, insulation for warmth and quiet). Make a scale drawing of your room or home.

3. What makes my home functional, pleasing and effective as a structure?
Architectural teams: Compare sketches and make a "generic" sketch of the structure of a home which has all the necessary and sufficient conditions for your emotional, physical and social survival.

4. What makes the essential community structures functional, pleasing and effective in meeting our needs?
Study groups: Identify 5 necessary structures from your community - school, hospital, place of worship, food store, playground, gymnasium - that would also need to be transported to meet your needs. Join a group to identify the social, physical and aesthetic structure of each building and sketch them. Make a scale mapof how you would arrange the structures, roads, etc.

5. How can I adapt the essential community structures to a new environment and still have them meet our needs as a community?
Research and design teams - locations announced! You have been relocated to three unusual and special environments. Using the architect specifications, describe or model how you will adapt or rebuild your community structures in your assigned location. You will work with a team representing all the necessary structures (health, recreation, education, art . . .) to design your habitat for an indefinite stay. Hint: Try to discover the unique opportunities and challenges in each environment to use in your design for a 100 day stay. Graph the average day and night temperatures of extreme earth habitats and Mars.

◆100 of you are being temporarily relocated to Antarctica. What are the environmental conditions there? How will you adapt your home to this dry desert with scarce resources and frigid temperatures? What structures will your home have to have to support your lives? How will you be self-sustaining and reuse everything? How will you make music? How will you dance? How will the sounds of your habitat change?

◆100 of you will be relocated to northern Canada, an isolated area with little or no resources, cold temperatures and cohesive Inuit communities. What can you learn from the Inuit about collaboration and competition, about expressing your life through story, song and decorative art on useful objects? How do they express themselves through music, song and dance around their lives and rituals? Why do Inuit decorate everyday objects with drawings, carvings and other artistic expressions.

◆100 of you will be relocated to North Africa in the Sahara - a region of nomadic desert tribes and sand storms. Why are they always on the move? How does their rug-making both express and reflect their lives and cultural traditions? What kind of individual self-expression are they able to do within their traditions? How do individuals contribute to each other lives in this environment?

6. What are the needs over time of a community?

Chronicle your stay in a 100 day diary. On a grid of 10 x 10, choose to record: the food you ate, the animals you saw, the rituals celebrated, the weather, the landscape, the temperature, your emotional mood expressed in color, the textures, colors, shapes or lines in the environment. OR Keep a Class 100 Day Diary (good for communication, cooperation and community-building) and the class decides every day what to record in that square. Create a shopping list with prices for the 100 day stay to figure a total budget (# cans of soup @ $ = $) + (x rolls of toilet paper @ $ = $).... = $ total budget for consumables.

7. How do architects think about the effect of their buildings on the people who use them?

Take virtual field trips to interesting architectural sites or study famous architects or designers: Chaco Canyon, Trajan's Forum in Rome, the Great Mosque in Djenne, Mali, and imperial villa in Kyota, Japan, Frank Lloyd Wright, Bauhaus school, IM Pei, Buckminster Fuller, Michael Graves, Frank Ghery, Philip Johnson. Look at the architecture in your community. How are structures alike or different? Use a Venn diagram to compare. Research local architects and interview them about this question.

8. How can the physical structure of a building support the social, emotional and aesthetic needs of those who use it?

Presentation: One of your teams will be chosen to rebuild your community back home. Present a redesign for your home town to the Transport team to re-inhabit your home, with social, emotional, physical and aesthetic structures that you have learned from the challenges and opportunities in your new environment (how to conserve energy, live together well, use art for self-expression or legacy). Label at least 3 structures from each of the four areas (aesthetic, physical, emotional, social) that will support a high quality life. Figure out what will fit into your model of a Martian habitat from what you value (stereo, VCR, exercise equipment, gathering places). Your presentation may be in the form of a play, multimedia presentation, debate, dance, or song.

Other Ideas for Teachers to Consider

W: How will you help students know where they are headed and why?

By recalling the story of Dorothy and the Wizard of Oz, you set the stage for giving students the simulated "Transport Order" to move their community. Explain how humans have always tackled new frontiers and moved to avoid negative conditions.

H: How will you hook the students through engaging and thought provoking problems that point to the big ideas?

The Transport Order, written by an actual evacuation officer, has an element of urgency. What if you could only take five structures, and knew you would be gone for 100 days. What you take? What makes your community a community? How would you decide what you to take? Who would you involve in the decision? Make a list of all the questions students have and put them to work as artists portraying their homes.

E: What learning experiences will engage students in exploring the big ideas? What instruction is needed to equip students for the performance task?

Ask students to sketch or model their homes, inside and out. Put architectural teams together to study and compare homes to build a generic home to meet people's emotional, physical and social needs. Form study groups to identify 5 necessary structures for the community. Involve the parents and community in identifying what is important. Challenge students to adapt their designs to Mars-like earth habitats by studying how people have adapted to them (Antarctica, North Africa and northern Canada).

R: How will you cause students to reflect and rethink to dig deeper into core ideas? How will they be guided to revise and refine their work?

Use a 100-day diary to have students reflect on how they will live inthe new habitat. Take them on virtual field trips to interestingarchitectural sites and consider how buildings affect the people who
use them. Send students notice of returning home after the 100 days andhave them think about how they will rebuild their own community toencourage self-expression and a legacy. Ask teams to present theirideas in a play, multimedia presentation, dance, song or debate.

E: How will students exhibit their understanding through final performances and products? How will you guide them in self-evaluation to identify strengths and weaknesses and set future goals?

Display student models, architectural designs and adaptations. Use theexhibit as a backdrop to the final presentations by teams on how theywould improve their own communities from their transport experience.

Unit title: Habitat Alternatives: A Problem-Based Learning unit on Seeing Red
Grade level: 3-5
Subjects: Interdisciplinary
Timeframe: 8 weeks

Links to National Content Standards:

Science
• Knows that the Earth is the only body in our solar system that appears able to support life.
• Knows that designing a solution to a simple problem may have constraints, such as cost, materials, time, space and safety. Evaluates a design based on constraints.
• Knows that science and technology have improved transportation, health, sanitation and communication.
Language Arts
• Uses multiple representations of information (maps, charts, photos. . . to find information for research topics.
• Writes compositions that show some attempt to use descriptive language that clarifies and enhances ideas.
Geography
Places and Regions
• Understands the physical and human characteristics of place
• Understands that culture and experience influence people's perceptions of places and regions.
Theater
• Designs and produces informal and formal productions. Uses movement to explain ideas and concepts.
Math
* Understands the basic relationship of fractions to decimals and fractions to whole numbers.
* Understands when one form of a number might be more useful than another.
* Understands how to collect information into a table for interpretation.

Brief Summary of the Unit:

The students enter a classroom bathed in red light - cellophane on the lights and windows, red streamers hanging from the ceiling, red foam balls littering the floor - welcome them to the Red Planet. You announce the opening of the first habitat on Mars and welcome them as the first prospective settlers. You are there to help them explore the idea of living on Mars. "Please look around, make yourself at home. You say, "I'd be happy to answer your questions, just fire away." Take at least 10 minutes to record all the questions the students have from the perspective of their roles as potential settlers, then give them the scenario.

The Scenario: Location, location, location

The solar system is being actively explored by the citizens of Planet Earth. Probes have explored moons and planets to better understand them and our own Earth. Technology breakthroughs have now made it possible for some people to choose to relocate to any planet in the solar system. Since explorations of Mars show that it is the most like our own planet, many species are trying to decide between living on Mars and living on Earth. Your group, Habitat Alternative, Inc. has been awarded exclusive rights for creating the Community Profiles of the sister planets of Mars and Earth to help people decide which community to join.

Your Mission:

Create two separate Community Profiles for an audience of humans: one for the Water Planet and one for the Red Planet. Describe how each habitat naturally or artificially will allow humans to have safe, meaningful and creative lives for at least 100 years. Prepare written materials and live tours for prospective settlers.

Your questions:

Scientists begin by asking questions. What questions will your profile need to answer for those people thinking about relocating? Use the questions you had in the opening exercise as a beginning list. Categorize the questions, add to the categories and prioritize the key questions.

Artists begin by exploring, collecting related ideas, playing and observing. List what you know about each planet and what you want to find out. What is beautiful and intriguing? What are the structures that support life and living to the fullest?

Anthropologists are interested in the stories people tell themselves and the stories their lives tell to understand what they need and value. How will you help people to make a choice between the Earth and Mars communities based on their needs and values?

Teaching and learning experiences in the unit:

Procedure/process

1. What questions will people have about the culture of each place? Take an anthropologist's view. In the whole group, list at least three questions for each area: language, social organization (government, power structures), religion, social conventions (manners, rituals, habits), relationship with the environment, use of technology, ideas about health and wellness, learning and ways of knowing.

2. What are the opportunities, threats and interesting characteristics of Mars and Earth as potential habitats for the next 100 years? Planet research teams: Divide into two teams: Earth and Mars communities.

• Earth team: Choose a hospitable place on the planet, and research it in the context of the whole Earth system (population projections, ozone depletion, global warming).

• Mars team: Research what a habitat would have to be to sustain human life. Describe how it would also meet people's social/political, emotional and aesthetic needs over the next 100 years.

3. Why would people be interested in living on Mars? Design a written piece such as a brochure, telecast or hypertext document that: 1) gives people information about the planet as a home; 2) helps them to decide about where they want to live based on what they need and want, and what they are willing and able to contribute to a community. Offer a guided tour of the habitat and be prepared to answer questions. Ask parents to be an audience for the relocation "pitch" and to share their choice and reasons.

Activities for investigating Mars

- Relocation

Consider dividing into teams to investigate the environment (temperature, terrain, seasons, sunlight, air, wind, dust, radiation, possible natural resources for sustaining life - energy, water), habitat structure(construction, materials) and interior design. Make a list of questions you think people will ask. Obtain a "Relocation Quarterly" if they have them in your area or check with local realtors or "The Welcome Wagon" to see the kinds of questions people ask. Think about what it means to live in an exotic place where novelty is the norm.

- Environment

Use what you learned in the Structures unit about investigating a particular place on Earth to investigate Earth as a whole system. What makes it one system? In what ways is it a closed system? How is it a living organism? How have we co-evolved with the environment? How is the atmosphere we take for granted an integral part of our culture? What does this environment that we have co-evolved with suggest for relocating to Mars? Use what you know about Earth systems to describe the Martian environment. Use satellite images and probe photos to choose a potential site for a habitat. Create models of the "river beds" to hypothesize about their formation. Create snapshots of the environment four times for one Martian year (687 Earth days). Identify the opportunities, threats and possibilities from a human perspective. Consider transportation and recreation in an environment with 38% of the gravity of Earth. Make a chart to compare the weight of an average person, and 4 other valued objects such as a boom box. Is it possible that the polar caps are a source of water? Is it possible there is water underground? How will the absence of sound affect the quality of life? How will they communicate outside the habitat where there is no atmosphere and sound does not travel? Could the Martian winds be used in any way?

- Structure

Use what you learned about Earth structures and architectural ideas to describe the internally pressurized structures that humans can choose from on Mars. How will a temperature range of -194°F to 72°F and an atmosphere that is 95% carbon dioxide, and a surface pressure of 7-10 millibars (compared with 1013 millibars on Earth) affect the shape and design of the structures? Create a circle graph of the makeup of Earth's atmosphere and that of Mars. Represent the amount of each element as a percentage, a decimal and a fraction. Decide which is most helpful.

- Social Structure

What will the environmental conditions require of the inhabitants? What roles will be needed? what skills? What occupations will be required? How will work and jobs be structured to sustain life and make it meaningful for people? How will they relax? What recreation will be available? What new sports will be possible due to the gravity difference?

- Interior

Use what you learned about what humans need and want to describe how the interior space of a Mars habitat would be satisfactory. Describe how people will get their daily nutrition needs met (3077 grams of water, 618 grams of food, 70 grams of protein, 500 grams of carbohydrates). How will they make music? create soothing and energizing sounds?

- History

Use what you learned about people's sense of community to talk about Earth as a community. What role does history play in helping people feel like a community? How does a house become a home? What role do traditions play in creating a positive social, emotional and aesthetic environment? How will you create this in the pressurized habitat on Mars? Should the history of Earth be carried with you to Mars?

- Culture

Use what you learned about how people need and want to relate to each other to describe the neighborhoods and communities of Earth. How is the variety of choices on Earth a benefit? How does the culture of a community relate to its environment? How will the culture of the habitat on Mars be affected by its necessarily closed system? its size? its purpose?

Reflection

Which planet would you choose? Why? What would make you change your mind?
What makes people care about the place they live? the people with whom they live?
Why do people contribute to a community? What makes a community grow and thrive?
Why do people move? How do they choose where they relocate?

More Ideas for Teachers to Consider

W: How will you help students know where they are headed and why?

Spark students' imagination by opening up Mars for habitation. Why would anyone want to live there? How would it compare with living on Earth? After presenting the scenario, explain that students have been hired as part of the firm, Habitat Alternatives, Inc. to interest people in living on Mars versus Earth. Two teams will compete for dwellers by doing research on the advantages of each habitat.

H: How will you hook the students through engaging and thought provoking problems that point to the big ideas?

Bathe the classroom in red light (cellophane on the lights, red streamers hanging form the ceiling, red foam balls littering the floor) to welcome students to the opening of the Red Planet. They are the first settlers! What questions do they have about their new home? Record them all and then challenge them to figure out how each planet -the Earth and Mars will sustain humans for the next 100 years.

E: What learning experiences will engage students in exploring the big ideas? What instruction is needed to equip students for the performance task?

Engage students in learning about how people choose where they live. Have them take an anthropologist's view and explore language, social organization, social conventions, relationship with the environment, use of technology, ideas about health and wellness, learning and ways of knowing. Have students divide into 2 teams and research life in a hospitable place on Earth and a place on Mars.

R: How will you cause students to reflect and rethink to dig deeper into core ideas? How will they be guided to revise and refine their work?

Ask each team to create a brochure, telecast or hypertext document that: 1) gives people information about the planet as a home; 2) helps them to decide about where they want to live based on what they need and want, and what they are willing and able to contribute to a community.

E: How will students exhibit their understanding through final performances and products? How will you guide them in self-evaluation to identify strengths and weaknesses and set future goals?

Ask students to prepare to offer a guided tour of the habitat and to answer questions. Ask parents to be an audience for the relocation "pitch" and to share their choice and reasons.

Using the Materials in Different Time Frames

Each teacher has the responsibility of helping each student to achieve knowledge and skill gains and meet high expectations. This package is intended to be a rich resource to teachers, providing a variety of deep and meaningful activities to engage students in thinking about their own communities and the potential for creating a new community on Mars.

- *To use the materials throughout the year*:

Consider making "Seeing Red" the theme for the year. Think about the materials as spanning the school year.

1. Use the unit on Home, beginning with Matisse's red studio, and selecting those activities that will engage your students in thinking about the concept of home. Create a gallery of your students's renditions of home and their "journey boxes." Involve the community and the rest of the school in the town meeting.
2. Use the unit on Structures, beginning with Transport Order and the strong emotions (red) that would evoke. Study the different cultures as part of the Social Studies curriculum on government, culture and habitats, and the Science curriculum on different environments on Earth. Integrate the architectural activities with the Math curriculum (scale, models, measuring).
3. Use the Problem-based Learning unit. Hold an architectural fair to display the designs with the 100-day visual diaries in the background. Make a Mars room or hall to teach other students, or the

community about the Red Planet, and a second Earth space with the same categories of information to show what students learned about the planets as habitats. Invite the parents and/or community to the relocation tours.
4. Build a model of a Mars habitat. Use the design specifications with students to challenge them to build a scale model of a habitat on Mars and describe how it will sustain human life.

To use the materials over a month:

1. Study one culture's physical and social structures, the art in their lives and their adaptation to an inhospitable environment using several of the "Observation" strategies from the unit on Home. (5 groups: physical structures, social structures, art, environment, adaptations) 1 week
2. Research the Mars sites and environment using activities from the PBL unit. (1 week)
3. Have students create and present to an audience Community Profiles for Mars and Earth. (2 weeks)

To use the materials for a week:

1. Have students choose two of the "Observation" activities to characterize their rooms (1 day in class and homework).
2. Have students investigate the structures of the community in teams, with community resource people if possible, and sketch the essential structures. (2 days)
3. Ask students to work in two teams to create the Community Profiles for Mars and Earth based on their top five questions.

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The Grand Canyon of Mars and How it Formed
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Professional Resources for Teachers

These materials were developed by writing teams using the *Understanding by Design* framework. The framework is a series of tools and templates that lead educators through a backwards design process for writing curriculum and assessment that leads to student understanding. Published by the Association for Supervision and Curriculum Development (ASCD), the framework is explained in a book, a short videotape, and soon in a CD-ROM and Designer's Handbook. Workshops are planned in various cities, and a cadre of trainers are available to bring the Understanding by Design training to your site. For more information, call 1-800-933-2723 then press 2. Or visit our website at **www.ascd.org.**

Other sources for teacher professional development in curriculum, assessment, the arts, sciences, and technology available through ASCD:

1) Interdisciplinary Curriculum: Design and Implementation
Heidi Hayes Jacobs, ed.
Explains the two important criteria every interdisciplinary program must adhere to. Presents six design options for an interdisciplinary curriculum and a useful process for integrating the teaching of science, math, language arts, social studies, and the arts. Plus two successful case studies of interdisciplinary programs.

2) A Comprehensive Guide to Designing Standards-Based Districts, Schools, and Classrooms
Robert J. Marzano and John S. Kendall
This book is an invaluable resource for districts, schools, or individual teachers who wish to organize curriculum, instruction, and assessment around standards. It is based on the Mid-continent Regional Educational Laboratory's (McREL) work with scores of districts, hundreds of schools, and thousands of teachers. The book deals with basic

questions such as these: Who will be involved in setting standards? What types of standards will we have? At what grade levels will they be written? Who will be held accountable and what will they be held accountable for? How will students be assessed on standards? How will students' progress on standards be reported? To help answer these questions, sample report cards, teacher grade books, performance assessment tasks, rubrics, and national efforts to design and implement samples are provided. This book asks and answers all important questions in enough detail to allow any district, school, or individual teacher to fully design and implement a standards-based system. 1996 ASCD/McREL book developed by McREL.

3) Design Tools for the Internet-Supported Classroom
Judi Harris
Judi Harris offers staff development professionals an important resource for helping educators create powerful, curriculum-based online activities. Drawing on research and extensive online experience, she demonstrates how teachers can best become designers for Internet projects. She shares 18 structures for successful telecomputing activities, an 8-step process for creating those activities, 5 purposes for students' teleresearch, and 10 types of Web pages teachers can use to support their projects. Harris also discusses which educators are likely to adopt an innovation first--and last--as well as how to work with them and what types of staff development to offer. She also provides numerous online resources and examples of successful, classroom-tested projects.

4) Design as a Catalyst for Learning
Meredith Davis, Peter Hawley, Bernard McMullan, and Gertrude Spilka
Involving students in active learning experiences is much easier and more rewarding when you teach them the skills and processes that professional designers--architects, graphic artists, and others--use every day. This ground-breaking book introduces you to the 7 steps in the design process and describes effective design activities and strategies for every grade level and subject area. Learn how the design process naturally integrates subjects, helps you teach thinking and communications skills, and encourages students to apply academic concepts in authentic tasks. Explore many examples of exciting design activities, including: * A 4th grade class where social and environmental studies come alive for students while they design and build Native American housing * A 7th and 8th grade class where students apply knowledge of math and science through a critique of environmentally unsound packaging * A high school physics class where students learn fundamental principles as they design their own Rube Goldberg projects

5) A Teacher's Guide to Performance-Based Learning and Assessment
Educators in Connecticut's Pomperaug Regional School District 15
This book is for classroom teachers across the spectrum of grade levels and disciplines who want to learn strategies for creating and using performance-based learning and assessment. The audience will also include educators responsible for leading and managing long-term change to improve student performance.

6) Developing Performance Assessments
One 55-minute video program and a Facilitator's Guide explain and show how to use

the four major components of the process of developing performance assessments. The four components are: Selecting the learning goals/objectives/content standards, Designing the task, Determining how to evaluate the task, Reviewing and revising the task and scoring tools. The program shows actual examples of task design sessions, classroom implementation of the task, and task revision sessions. Examples are drawn from elementary, middle school and high school classrooms engaged in science, language arts, and math lessons. Featured experts Grant Wiggins and Jay McTighe explain concepts and practices. The 88-page Facilitators Guide includes outlines for a 1.5-hour workshop and a 4-hour workshop that leads participants through the entire development process and teaches them how to develop their own performance assessments. The Facilitator's Guide also contains handouts, overheads, and background readings.

7) Mapping the Big Picture: Integrating Curriculum and Assessment K-12
Heidi Hayes Jacobs
Teachers have always used the school calendar to plan instruction. Now, using a standard computer word-processing program, they can collect real-time information about what is actually taught to create "curriculum maps." These maps provide a clear picture of what is happening in their classes at specific points during the school year. The benefits of this kind of mapping are obvious for integrating curriculum: when curriculum maps are developed for every grade level, educators see not only the details of each map, but also the "big picture" for that school or district. They can see where subjects already come together--and where they don't, but probably should. In Mapping the Big Picture, Heidi Hayes Jacobs describes a seven-step process for creating and working with curriculum maps, from data collection to ongoing curriculum review. She discusses the importance of asking "essential questions" and of designing assessments that reflect what teachers know about the students in their care. She also offers a viable alternative to the "curriculum committees" that are part of almost every school district in the United States. The book concludes with more than 20 sample curriculum maps from real schools, all of which were developed using the process described in this book.

8) Whelmers: 41 Awesome Easy-To-Do Science Activities
This easy-to-use CD-ROM contains full-motion video demonstrating 41 classroom science activities that will intrigue students ("whelm" them, not "overwhelm" them) and help teachers introduce basic principles of air pressure, chemistry, energy, density, and waves. Science background information explaining the concepts, process skills, teacher tips, materials lists, safety measures, and correlations with assessment and specific national standards (NRC) for grades K-4, 5-8, and 9-12 are included. Each hands-on activity uses everyday materials available in grocery and hardware stores. Expert science teacher Steve Jacobs, of the Jake's Attic television series, demonstrates the experiments with students in a friendly, engaging manner. Software application included: QuickTime.

9) ASCD Topic Pack -- Arts Education
This Topic Pack includes numerous full-text articles on arts education, carefully chosen from "Educational Leadership," "Education Update," and other ASCD publications; a

list of ASCD resources on arts education, including books, videotapes, and audiotapes, with brief descriptions; ERIC digest summaries and a list of ERIC documents on arts education, along with information on how to obtain articles from ERIC; a bibliography of journal articles on arts education; and a list of selected Internet resources on arts education.

10) Make It Happen! Inquiry and Technology in the Middle School Curriculum
Judith Zorfass, Educational Development Center, Newton, MA
A print, video and software package to aid technology integration for constructivist, interdisciplinary middle school classrooms. Make It Happen! is a tool for middle school teachers to guide students through research within thematic curriculum units. This constructivist tool helps teachers and students focus research questions, develop a plan for gathering information, integrate and synthesize the information, prepare findings for presentation. The targeted audience for this product is middle school teachers, parents, technology coordinators, and others involved in guiding student research. Materials in the Make It Happen! package include: A Facilitator's Manual - with guidelines, handouts, agendas, discussion topics, etc. (3-ring binder, 242 pages), A Teacher's Guide - presents a model unit and tips for curriculum design, An Overview Video - 47 minute video with 4 vignettes from actual middle school classrooms using Make It Happen!, Search Organizer Software - Software for student use to generate research question, plan research, record and analyze information and create draft report. Includes a site license for 150 simultaneous users, (MACINTOSH format ONLY/System 7.1 or higher), a 46-page User's Manual, and a 10-minute demonstration video on how to use the software.

11) Planning Integrated Units: A Concept-Based Approach
This video-based staff development program includes a 65-minute videotape and an 84-page facilitator's guide. Planning Integrated Units examines how to design integrated units that not only help students see connections among different subject areas but also challenge students to think at higher levels and promote a deeper understanding of what they're studying. The program begins by explaining the concept-based approach. Through lessons in elementary and middle school classes, teachers demonstrate how to use concepts to view topics and focus students on the essential understandings, or big ideas, that students can transfer to other learning situations. Curriculum expert Lynn Erickson explains how framing units around concepts and essential understandings enhances student understanding and is compatible with how people actually learn and apply knowledge. A major portion of the program focuses on how to plan a concept-based integrated unit, using an 8-step process developed by Erickson. Choose a theme that easily incorporates a variety of subjects. Identify a concept for viewing the theme. Select topics from your curricula for literature, math, science, and other subjects that reflect the theme and concept. Identify essential understandings -- the big ideas related to the theme and concept. Develop guiding questions that will help students grasp the essential understandings. Determine the complex performances and key skills you want students to learn during the unit. Design the culminating performance task that will enable students to demonstrate what they know, understand, and can do as a result of the unit. Write instructional activities that will engage students in learning the essential understandings and key skills.

Mars Millennium Project Materials - Grades 6-8

Making Martians

Kathy Talley-Jones

Outline

I. Introduction / Summary
II. Subjects
III. Link to Content Standards
IV. Student Outcomes
    Content
    Skills
    Essential Questions
V. Time Management
VI. Learning Experiences and Instruction
    1. What Is Mars?
    2. Why Are We Here?
    3. Who Are We?
    4. Where Will We Live, and What Will We Live In?
    5. What Makes Us Martians?
    6. Make Your Pitch

I. Introduction / Summary

Groups of human beings very quickly develop unique forms of cultural expression, and there is no doubt that the first colony of Earthlings on Mars will become Martians. What will be unique about their experience?

Through an inquiry- and problem-based unit, students will explore the physical Martian environment and its implications for sustaining human life, in all its varied forms of expression. They will look at the opportunities and threats of living on Mars, gain a thorough understanding of what we think Mars is like, what humans might do when they are there, create a mission for their colony, and then develop a convincing presentation for the continued support of the Mars colony by the people of the Earth.

Making Martians is a truly interdisciplinary unit that could most likely find its home in social sciences, arts, language arts, or science context because it incorporates significant learning and understanding in each of these areas. It meshes with curriculum goals for middle school in these areas and incorporates content knowledge and encourages the construction of knowledge by students. Although the activities dovetail and build on one another, teachers with time constraints can consider using different portions of the unit depending on their own teaching styles, goals, and requirements. The unit explores significant questions about the meaning of culture, the

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applications of scientific knowledge, the history of human exploration and relocation, and the use of this knowledge to develop real-world, practical applications that connect school to work in communications fields.

II. Subjects

Art, language arts, history/social sciences, science

III. Link to Content Standards

Link to Content Standards (drawn from Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education, McRel/ASCD, http://www.mcrel.org)

Art

Grades 5-8

- Knows how visual, spatial, and temporal concepts integrate with content to communicate intended meaning in one's artworks
- Knows different subjects, themes, and symbols (through context, value, and aesthetics) which convey intended meaning in artworks
- Understands the historical and cultural contexts of a variety of art objects
- Understands how factors of time and place (e.g., climate, resources, ideas, technology) influence visual, spatial, or temporal characteristics that give meaning or function to a work of art

Getty Education Institute Scope & Sequence (http://www.artsednet.getty.edu/ArtsEdNet/Resources/Scope/index.html)

Students

- identify subjects and themes that reflect their personal thoughts and give new directions to their art making.
- articulate judgments about the impact of the visual, tactile, spatial, and temporal elements on their experience with the natural and built environment.
- generate questions about art from perspectives representing various fields of inquiry such as art history, art making, art criticism, aesthetics, anthropology, chemistry, etc.
- give examples of how artworks can reflect or challenge dominant tastes and values of a culture.
- construct interpretations that are appropriate for the cultural-historical context in which artworks were made.
- articulate multiple viewpoints about philosophical issues associated with art.

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Language Arts

Grades 6-8

- Gathers data for research topics from interviews (e.g., prepares and asks relevant questions, makes notes of responses, compiles responses)
- Uses a variety of resource materials to gather information for research topics (e.g., magazines, newspapers, dictionaries, schedules, journals, phone directories, globes, atlases, almanacs)
- Determines the appropriateness of an information source for a research topic
- Organizes information and ideas from multiple sources in systematic ways (e.g., time lines, outlines, notes, graphic representations)
- Applies reading skills and strategies to a variety of informational texts (e.g., textbooks, biographical sketches, letters, diaries, directions, procedures, magazines, essays, primary source historical documents, editorials, news stories, periodicals, bus routes, catalogs)
- Knows the defining characteristics of a variety of informational texts (e.g., textbooks, biographical sketches, letters, diaries, directions, procedures, magazines, essays, primary source historical documents, editorials, news stories, periodiocals, bus routes, catalogs)
- Summarizes and paraphrases complex, explicit hierarchic structures in informational texts

History / Social Sciences

Students

- Understand that each culture has distinctive patterns of behavior that are usually practiced by most of the people who grow up in it
- Understand that technology, especially in transportation and communication, is increasingly important in spreading ideas, values, and behavior patterns within a society and among different societies
- Understand that various factors (e.g., wants and needs, talents, interests, influence of family and peers and media) affect decisions that individuals make
- Understand that a variety of factors (e.g., belief systems, learned behavior patterns) contribute to the ways in which groups respond differently to their physical and social environments and to the wants and needs of their members
- Understand how language, literature, the arts, architecture, other artifacts, traditions, beliefs, values, and behaviors contribute to the development and transmission of culture

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- Understand that there are similarities and differences within groups as well as among groups
- Understand how various institutions (e.g., banks, schools, hospitals, the military) influence people, events, and elements of culture and how people interact with different institutions

There are natural content connections in the Making Martians unit to the exploration and settlement of the Americans by Europeans as well as colonization in ancient history (Greek, Roman, and Chinese, for example).

Science

Student:

- Knows characteristics and movement patterns of the nine planets in our Solar System (e.g., planets differ in size, composition, and surface features; planets move around the Sun in elliptical orbits; some planets have moons, rings of particles, and other satellites orbiting them)
- Knows that the planet Earth and our Solar System appear to be somewhat unique, although similar systems might yet be discovered in the universe
- Establishes relationships based on evidence and logical argument (e.g., provides causes for effects)
- Understands the nature of scientific explanations (e.g., emphasis on evidence; use of logically consistent arguments; use of scientific principles, models, and theories; acceptance or displacement based on new scientific evidence)
- Knows that people of all backgrounds and with diverse interests, talents, qualities, and motivations engage in fields of science and engineering; some of these people work in teams and others work alone, but all communicate extensively with others
- Knows that the work of science requires a variety of human abilities, qualities, and habits of mind (e.g., reasoning, insight, energy, skill, creativity, intellectual honesty, tolerance of ambiguity, skepticism, openness to new ideas)
- Understands ethics associated with scientific study (e.g., potential subjects must be fully informed of the risks and benefits associated with the research and their right to refuse to participate; potential subjects must be fully informed of possible risks to community and property)
- Knows that the Earth is the only body in our solar system that appears able to support life
- Knows that the Earth is comprised of layers including a core, mantle, lithosphere, hydrosphere, and atmosphere

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- Knows the composition and structure of the Earth's atmosphere (e.g., temperature and pressure in different layers of the atmosphere, circulation of air masses)
- Knows ways in which clouds affect weather and climate (e.g., precipitation, reflection of light from the Sun, retention of heat energy emitted from the Earth's surface)
- Knows how the tilt of the Earth's axis and the Earth's revolution around the Sun affect seasons and weather patterns (i.e., heat falls more intensely on one part or another of the Earth's surface during its revolution around the Sun)
- Knows factors that can impact the Earth's climate (e.g., changes in the composition of the atmosphere; changes in ocean temperature; geological shifts such as meteor impacts, the advance or retreat of glaciers, or a series of volcanic eruptions)
- Knows the processes involved in the water cycle (e.g., evaporation, condensation, precipitation, surface run-off, percolation) and their effects on climatic patterns

IV. Student Outcomes

Content

As a result of this unit, students will know:

- the physical environment of Mars
- through time, people have founded colonies
- through time, people have experienced change
- the varieties of cultural expression
- roles within a community on Earth and on Mars
- how individuals interact within a community to form a cohesive group
- that the arts are a means to communicate about culture and self

Skills

As a result of this unit, students will be able to:

- create a compelling argument and present important ideas
- acquire information from books, magazine articles, and the Internet
- organize information using text and visuals
- use technology effectively
- work productively in cooperative groups with open-ended questions and problems
- apply scientific knowledge to human problems and issues
- develop a mission for a scientific and humanistic endeavor

- justify their thoughts, ideas, and opinions
- envision and create a complex community
- plan and produce a document that explains their thoughts, ideas, and opinions

Essential Questions

- What are the human implications of the physical environment of Mars?
- What impact does the physical environment have on cultural expression?
- What roles are needed within a community?
- What are the reasons for space exploration and colonization?

V. Time Management

Using materials with different time frames:

Each of the sections within Making Martians is sequenced so that teachers with less time can accomplish the first few parts of the section and move onto the next. Although the sections build upon one another, a teacher with only one week could tackle sections 1 and 2 in which the Martian physical environment is understood and the mission developed and undertake a more limited version of the Martian colony's pitch to Earthlings for support. The sections are very open-ended, and teachers with less time could provide students with less self-determination and give more direction.

VI. Learning Experiences and Instruction

1. What Is Mars?
2. Why Are We Here?
3. Who Are We?
4. Where Will We Live, and What Will We Live In?
5. What Makes Us Martians?
6. Make Your Pitch

Introduction

Greetings, Martians! You and your classmates have been chosen to be the first Martians--part of the first colony of humans on Mars! You have been honored with the chance to be part of the first group of Earthlings to become extraterrestrials, but you also have many challenges ahead. You wouldn't have been given these challenges if you couldn't handle them, though, so let's get moving!

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One day, perhaps, the Mars colony will support itself. But the first colony on Mars will still need help from Earth—and not everyone on the home planet thinks that this colony is a good idea. Your overall mission will be to gain a thorough understanding of just what Mars is, what you are doing there, and then convince the people of Earth that they need to support your efforts. Your argument and the way you communicate the message will be up to you: will you prepare a glossy magazine that shows the benefits of your operation? A Web site that tells all about the Mars mission and why it is a good thing? A TV show that shows just how wonderful it is? Or will there be some new 21st century technology that you will use? It's your choice!

First, we'll take a look at the red planet so that we can get an idea of what faces us. We'll then focus on our mission and what we are doing on Mars. Following that we'll examine where we live, what we do, how we live, and look at what makes us Martians. Once we know everything about our new home, we'll pull it all together and make our pitch to the folks back home on Earth.

1. **What Is Mars?**

In this section, students will look at the physical environment of Mars. Divide the class into teams to research and prepare written and verbal reports on the following aspects of the Martian physical environment. Not only should they report on the facts of their topic but also compare them to what they know about earth and speculate on their implications for human life on Mars.

Information on the Martian physical environment will provide a framework for determining the function of the Mars mission and how it will survive in an environment very different from that of the Earth.

Encourage students to use graphics and visual aids in their presentation—images that they create themselves or locate on the Internet or in books and magazines. These reports and visuals will provide the background story on the Martian environment that will be key to the final presentation that students create.

Mars's place in the solar system

- distance from the sun
- distance from the earth
- relationship to other planets and features of solar system
- size
- moons
- length of the year

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Martian weather

- temperature variations
- wind/storms
- water
- seasons
- clouds
- length of day/night

Martian atmosphere

- atmospheric gasses
- atmospheric pressure
- humidity
- clouds

Martian geology

- composition of planet
- tectonics
- dirt / sand
- rocks
- gravitational field
- magnetic field
- moons

Martian geography

- mountains
- volcanoes
- valleys
- craters
- channels

Martian resources

- minerals
- water
- energy
- geothermal
- other

Life (nonhuman) on Mars

- in the past
- in the present

How do we know what we know about Mars?

- naked eye observations

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- observation from telescopes
- unmanned probes
- comparison with Earth systems

Challenges and Extensions

How long does it take to travel from the Earth to Mars today? Do unmanned and manned flights take different amounts of time? What are present-day rocket propulsion systems? What might they be 30 years from now? How long do you think it will take to travel to Mars in 30 years?

Resources

Resources on the physical environment of Mars suitable for this developmental level include:

Berger, Melvin (1992). *Discovering Mars: The Amazing Story of the Red Planet.* New York: Scholastic.

Greeley, Ronald and Raymond Batson (1997). *The NASA Atlas of the Solar System.* New York: Cambridge University Press.

Newcott, William. (1998). "Return to Mars." *National Geographic*, August, pp. 1-29.

Raeburn, Paul (1998). *Mars: Uncovering the Secrets of the Red Planet.* Washington, D.C.: National Geographic.

Wunsch, Susi Trautmann (1998). *The Adventures of Sojourner: The Mission to Mars that Thrilled the World.* New York: Mikaya Press.

Atlas of Mars
http://ic-www.arc.nasa.gov/ic/projects/bayes-group/Atlas/Mars/

JPL Mars Missions Page
http://mpfwww.jpl.nasa.gov/

Mars Facts
http://www.windows.umich.edu/cgi-bin/tour.cgi?link=/mars/mars.html&sw=false&sn=557206&d=/mars&edu=mid&br=graphic&cd=false&tour=&fr=f

Mars Team Online: Archive of Questions & Answers
http://quest.arc.nasa.gov/mars/ask/index.html

2. **Why Are We Here?**

The basic assumption of this unit is that NASA is sponsoring a Mars colony. But why would anyone want to establish a colony on Mars? It's very cold, windy, dusty, the air's unbreathable, and there doesn't seem to have any running water—not to mention plants, animals, or other visible life forms. Despite these challenges, we're going to Mars! In this section, students will identify the mission for their Mars colony.

Explore with students reasons why NASA or anyone else might want to establish a Mars colony. Reasons could include:

- to increase scientific knowledge
- mineral or other resource exploitation
- to escape earth problems such as pollution and wars
- as a staging area for further space exploration
- because it's there—and because we can

Ask students to think of some reasons why people have colonized other parts of the world or have moved in groups from their homes. Ask them to draw on their knowledge of U.S. history as well as the history of other nations. Reasons might include:

- resource exploitation (gold, animal skins, oil)
- to escape religious or political persecution
- involuntary relocation such as slavery
- a desire to found a utopian community
- hope for economic success
- a human drive to explore new lands
- a combination of many factors

Given what the students know about the risks and hazards—and also the opportunities--of settling on Mars, ask them why they think NASA, working with the space agencies of other nations (or anyone else) might want to found a colony there. (And is NASA the only organization that could do this? Ask students to consider whether individuals, special interest groups, or even fugitives from justice might found a Mars colony.) Brainstorm a list of reasons.

Now ask students to pinpoint what their mission on Mars will be. This decision will control how the rest of the unit plays out, so consider this very carefully. It will drive

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- what kind of structure colonists live in
- who goes and what their occupations are
- what items colonists need and what
- the presentation made to Earthlings in support of the mission

Students may arrive at this decision through consensus building or by a majority vote. If teachers have more time, they may want to explore the mission proposals more fully through dividing the class into sections that present their rationale for the mission.

Finally, ask students to name their new community of Martians.

Challenges and Extensions

Many organizations have their own logos, mottoes, and flags. What would the flag for students' Martian colony look like? As an art extension, ask students to design flags and logos for their colony. Suggestions for designing banners and flags can be found on ArtsEdNet, the Getty Education Institute's Web site:
http://www.artsednet.getty.edu/ArtsEdNet/Browsing/Wave/project.html

Resources

Publications and Web sites that explore possible Mars missions include:

Clarke, Arthur C. (1994). *The Snows of Olympus: A Garden on Mars. The Illustrated Story of Man's Colonization of Mars*. New York: W. W. Norton.

A vision of the colonization of Mars including virtual landscapes in word and image. Speculative renderings of terraforming of Mars by Clarke.

Hartmann, William K., Andrei Sokolov, Ron Miller, and Vitaly Myagkov (eds). (1990). *In the Stream of Stars: The Soviet/American Space Art Book.* New York: Workman Publishing.

Embedded in these works by Russians and Americans are reasons why artists think humans should travel to and colonize other worlds.

Ley, Willy and Wernher von Braun. (1956). *The Exploration of Mars*. New York: Viking Press.

Includes classic paintings by Chesley Bonestell, one of the greatest mid-20th century artists to imagine, given the best scientific data of the time, what

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other planets might look like. *The Exploration of Mars* sold widely and is not difficult to find in school and public libraries and used bookstores.

Sagan, Carl. (1994). *Big Blue Dot: A Vision of the Human Future in Space*. New York: Random House.

Includes chapters on the past and future human explorations of Mars.

Wilford, John Noble. (1990). *Mars Beckons: The Mysteries, the Challenges, the Expectations of our Next Great Adventure in Space*. New York: Alfred A. Knopf.

Zubrin, Robert. (1996.) *The Case for Mars. The Plan to Settle the Red Planet and Why We Must*. New York: Free Press.

Zubrin presents a step-by-step plan to reach and settle Mars.

The Case for Mars
http://www.nw.net/mars/marsdirect.html

The Mars Society
http://www.marssociety.org/

West to Mars
http://www.marswest.org/home.html

A collaborative project that encourages the exploration of Mars through the arts. Includes the work of many artists envisioning Mars.

3. Who Are We?

Now that students have decided *why* they are going to Mars, they need to decide *who* will go. And what will they be doing once they get there?

Ask students to think about their own community and brainstorm a list of necessary or desirable roles for their Mars community. In addition, many students are very likely familiar with TV shows, movies, books, and comic books that take place in outer space and other planets and have an idea of the roles that people fill in these futuristic communities. They can draw on these ideas but ask them to confine their thoughts to technologies and human capabilities possible 30 years in the future. Ask students to think about other societies, cultures, or historical eras they know about or have studied.

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The list of roles desired in their Mars community could include:

- people in the community's primary occupations: farmers in a farm town, computer programmers and operators in a high-tech community, fashion designers and garment workers in a garment district, and so on
- cooks
- farmers and gardeners
- sanitation staff
- clerical and support staff
- educators
- transportation crew
- construction
- managers
- administrators
- supervisors
- communicators
- entertainers
- artists
- athletes
- architects
- spiritual leaders
- families
- security and law enforcement
- military
- medical professionals
- astronauts
- social workers
- financial managers
- lawyers

Will there be families in this community? And people to provide the services families need?

Have students select or assign roles to students. Encourage students to create names and identities for the roles that they select. In addition, ask them to think beyond their own identities—encourage national, cultural, gender, and age diversity. Keep students focused on the mission of their Mars colony. In the next section, student teams will research and develop design proposals for Mars colony sites, structures, and systems and roles should fit within these tasks.

If time is available, have students research these roles. Have them talk to or write someone in their community who fills a role similar to the one they

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have chosen. They may even want to invite people to speak to the class about their work.

Students may consider asking questions like the following:

- What kind of training do you have?
- Why did you chose your profession?
- What do you like about it?
- What don't you like about it?
- What do you think people with jobs like yours will be doing in 30 years?
- Can you imagine people doing what you do on Mars? What would it be like?

Consider having students play out their roles interacting with one another--working on skits and scenarios that incorporate their life on Mars. They can also write profiles of the roles they are developing and create illustrations that show what they look like living and working on Mars.

Challenge or Extension

How have people lived and worked together in challenging or hostile environments, isolated from other human beings? What are some of the hazards? What are some of the benefits? What do these experiences suggest? Possible topics for student research and oral or written reports:

Self-sufficient tribal peoples
Tahitians and English from the *HMS Bounty* on Pitcairn Island
Biosphere 2
Polynesian explorers
Skylab and Mir missions
Researchers in the Arctic or Antarctica
Expeditions such as the Everest Expedition described in *Into Thin Air* by Jon Krakauer
Early European settlers in the Americas

Resources

4. Where Will We Live, and What Will We Live In?

Like the Earth, Mars has a diverse climate and geography. Some parts of the planet will be easier for humans to live on than others. Based on their research on the physical environment of Mars in the first section, ask

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students to brainstorm a list of possible criteria for selecting a colony site. The list could include:

- useful resources
- easily traveled terrain
- suitable temperatures
- access to possible water sources
- interesting features to look at and explore

Divide the class into teams to research and develop proposals for the following aspects of their life on Mars:

- colony site
- waste and recycling systems
- air systems
- water systems
- food production (plants? animals? synthetic food?)
- transportation systems
- communication systems (on Mars and between Earth and Mars)
- design of public spaces for living
- design of public spaces for work
- design of public spaces for recreation, entertainment, culture, continuing education, worship, socializing
- design of private spaces
- allocation or design of outdoor spaces for work, resource extraction, food production, recreation

As much as possible, students should work within their roles in their mission to Mars. Ideally, teams should communicate with one another because their tasks are interdependent. The teacher or one student could serve a facilitator to work between groups to ensure that their proposals will mesh reasonably well.

In developing their proposals, students should factor in:

- resources available on Mars
- similar systems developed by earth cultures to adapt to challenging environments
- similar systems in their own lives
- efficiency
- cost
- feasibility
- aesthetics

This is a long-term if not permanent colony on Mars, and designers should provide for the colonists' mental, physical, and emotional well-being. If necessary, ask them to reflect what they do in their day-to-day lives and how needs and wants like their own will be provided for on Mars. Studying and looking critically at the spaces in their own lives will help them understand what will make their Mars colony livable.

Emphasize that the aesthetics of their designs—even of waste and water systems--can mean more than having them be pleasing or decorative. It can also mean designs that

- incorporate references to the colonists' cultural heritage (Golden Arches for Americans? The sweep of the Sydney Opera House for Australians? Domes and minarets for the Saudi Arabians?)
- are pleasing because they are perfectly functional, such as the aerodynamics of a jet plane or sleek car
- incorporate elements of the Martian environment: windows with views, Martian materials, Martian colors
- include surprising and fun touches: a maze, a secret door, a cleverly recycled storage container

Challenges or Extensions

Some of those who have thought about human settlements on Mars suggest that parts of the planet be *terraformed*, that is, changed to be more like Earth. Suggestions include creating a kind of "greenhouse" or global warming effect that transforms the Martian atmosphere. Research terraforming and then debate the ethical issues involved.

Robert Zubrin suggests that a failure to terraform Mars "constitutes a failure to live up to our human nature and a betrayal of our responsibility as members of the community of life itself"—yet, today, humans set aside parks to preserve Earth's wilderness and conserve the planet's resources. What do you think?

Resources

Zubrin, Robert. (1996.) *The Case for Mars. The Plan to Settle the Red Planet and Why We Must.* New York: Free Press.

Astrobiology
http://www.reston.com/astro/index.html

The Case for Mars

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http://www.nw.net/mars/marsdirect.html

The Mars Society
http://www.marssociety.org/

5. **What Makes Us Martians?**

Just as African, American Indian, Asian, and European peoples living in North America have become Americans, Earth settlers on Mars will be Martians. Groups of humans very quickly develop unique customs, jokes, games, fashions, understandings, ceremonies, and rituals. What will Martian culture be like?

As a class, brainstorm a list of elements of Martian culture. The list could include:

- holidays
- ceremonies
- special foods
- jokes
- architecture
- sports and games
- favorite vacation spots
- music
- performances
- artforms
- fashions
- pets (pet rocks?)
- religious practices

(As a point of reference, ask students if they know how these cultural elements may be different in the United States than they are in their ancestral cultures. How are they the same?)

Ask if any students have ever moved to a home in a new community or country. What is it like? For a time you miss your friends, the old house, the weather, but after a while you make new friends, find new things to do, and learn to appreciate your new environment. How will this compare to the Martians' experience?

As a class, talk about how traveling to and settling on Mars will make the Martians different from Earthlings. What will some of the subjects and influences be for Martian art, music, fashion, sports, and other forms of cultural expression? Answers could include

- poems and songs longing for Earth—for large open bodies of water, forests, animals, families and friends
- artworks celebrating Mars—the grandeur of Olympus Mons, the spectacular Valles Marineris
- a holiday giving thanks for surviving a year on the planet or celebration of the discovery of a geothermal source
- jokes defying Earth restrictions, customs, demands
- patches, clothing, or insignia worn by people in different Mars professions
- sports taking advantage of the low gravity and hiking and rock climbing in the new terrain
- paintings incorporating the butterscotch sky and blue clouds, the two moons, the light from a dimmer and colder sun
- stories commemorating people who have died or who have had exciting adventures
- new words (for example, words such as *geo*logy and *terra*in have roots in Latin and Greek words for *earth*—how might Martians want these words to be different?)
- a museum with artifacts significant to Martians or with artwork celebrating the Martians' cultural heritage on Earth
- electronic art and Web sites incorporating sound, video, and writing about the Martian experience
- naming Mars rocks and features for Earth cartoon characters
- e-mail with lists of jokes only Martians will understand

Students, in their Martian roles, can work together or independently to chose and develop some of these cultural expressions. Many of these can be incorporated or alluded to in students' pitch to Earthlings to continue funding and supporting the Mars colony developed in the final section of this unit.

<u>Challenge or Extensions</u>

Mars and Martians have often been depicted in popular culture. What are some of the ways Mars has been shown? Martian explorers? Native Martians?

The Mars in the Mind of Earth Web site
http://www-personal.engin.umich.edu/~cerebus/mars/index.html
has extensive listings of resources, as does *Destination Mars: In Art, Myth, and Science* by Martin Caidin and Jay Barbree. (1997). New York: Penguin Studio.

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Resources

Bean, Alan. (1990). "An Artist on the Moon," pp. 110-131 in *In the Stream of Stars,* William K. Hartmann, William K., Andrei Sokolov, Ron Miller, and Vitaly Myagkov (eds.) New York: Workman Publishing.

Bean, Alan. (1998). "An Artist on the Moon," pp. 14-51 in *Apollo: An Eyewitness Account by Astronaut / Explorer Artist / Moonwalker Alan Bean.* Shelton, CT: Greenwich Workshop Press.

Apollo 12 astronaut and artist Alan Bean describes how an artist looks at the light and color and texture of another planetary body.

Bradbury, Ray. (1946). *The Martian Chronicles.* New York: Bantam Books.

Bradbury's short stories explore astronauts' nostalgia for earth and their reaction to the alien Martian environment—and the Martians who live there. Also about the almost inevitable clash of cultures.

Robinson, Kim Stanley (1993). *Red Mars.* New York: Bantam Doubleday Dell.

A science fiction novel about the first Mars colonists and the terraforming of Mars.

6.Make Your Pitch

The Making Martians unit culminates with this activity in which students develop their pitch to Earthlings to continue funding and supporting the Mars colony. Depending on resources available the teacher or class should select some means of conveying to the people on Earth just what the Mars colony is and why it should continue to exist.

Possibilities include:

- a PR kit on the Mars colony with brochures, press releases, photographs
- a television show or infomercial about the Mars colony (imaginary or actually videotaped and broadcast if resources and community support permit)
- a Web site that includes information on Mars and the customs and activities of the Martians
- a magazine or newspaper with features on the Mars colony, reports on Mars sporting events, review of Mars performances, gossip about Mars personalities, and so on

Mars Millennium Materials - Grades 9-12
Designed by Grant Wiggins, Kevin Mattingly, Lisa Lyle, Daisey McTighe, and Bao Dam

Notes to the Teacher

Science, art, and social science are the three major units of study in this project for grades 9-12. Using an inquiry-based learning format, teachers will help students gain a deep understanding of many of the issues which must inform a design proposal for a thriving community of 100 people on Mars in the year 2030. The unit is designed to be a joint project between teachers in the science, art, and social science departments. Working with students in their own classes, teachers can use the content that matches their curriculum, then combine the project tasks their students have completed to create a total Mars community to be sent to the national registry and gallery.

Please familiarize yourself with all the materials in the project packet, especially the Decision Matrix, the Jigsaw Diagram, the 3 scoring rubrics, and the student tasks before considering the decisions noted below.

Things to Decide Before You Begin

How to use and whether to provide materials to students involves decisions each teacher has to make in this project. Teachers have numerous important choices to make at the outset, based on the amount of time s/he can allocate to the students' investigation of the issues, knowledge of the students' prior knowledge of and interest in the topics, and their degree of experience and comfort with inquiry-based learning. Teachers must also judge here their own tolerance and time constraints for the inefficiencies versus the power of student-directed learning. Those decisions are described below. There is a great continuum of many possibilities.

The intent of the inquiry-based learning approach at the foundation of these units (sometimes called Problem-Based learning) requires that students spend some time grappling with the higher-order decisions which arise during problem-based learning experiences. However, teachers must determine what makes sense for them and their situation.

You need to make various decisions about the scope of the project. The fullest possible project involves various stages of team work (in jigsaw i.e. separate teams working on separate pieces, or in sequence by all students), and three different simulation scenes in sequence: team-formation and initial team proposal, development of one overall best proposal for judgment internally, the development of a public relations campaign for the proposal. Consider:

a. How many of the three different possible scenes will you do (small team proposals leading to a design competition, an overall class design, public relations for the final single proposal)?

b. How many of the three general areas of inquiry will you do (science, art, social science)?

c. Will you do the three general areas of inquiry simultaneously in jigsaw fashion (so that students are expert in only one area of the proposal), or in sequence (so that all students must become expert in all areas)?

d. How much or little scaffolding will be provided to direct your students (in a continuum from providing all the questions, resources, and research to providing some or none)?

* On a pure student-directed end of the spectrum, a teacher might wish to simply frame the unit, mention the general questions at the head of each of the topics, make no mention of available resources other than reference to sources such as the Internet, the library, etc. This would allow the students the chance to roll up their sleeves, dive in, and make the work immediately their own. With this approach, there will be false starts and dead ends; time must be allowed to work it all through, with teacher coaching and intervention as needed. Students may also perhaps roam far afield of the core topics and spend a lot of time chasing irrelevant bits of information before hitting at what is central; it is equally true that connections made through such inquiry will be deep and lasting.

* On a highly teacher-directed end of the scale, teachers might choose to identify and circumscribe the resources (photocopy articles, place books on reserve or bookmark Web pages, etc.) s/he feels will best support efficient inquiry, provide students with a thorough list of guiding questions (provided in these materials for each unit as a teacher resource), and make up and distribute process guidelines (concept maps, checklists, etc.) under each topic in the proposal in addition to giving out and discussing the proposal requirements. While efficiencies would be gained in extensive scaffolding and direction, learners might develop a less in-depth understanding and take less ownership of the work. On the other hand, this may be all that time and the need for student success and closure allow.

e. How much, if at all, will your class do this project alone or in parallel with one or more other classes? (e.g. a biology class focuses on life science issues, an art class focuses on the design of colony artwork, an earth science class focuses on physical science issues, etc)?

f. How much time will you commit to the project? A teacher may choose to comprehensively address one or more of the essential questions, providing a year-long focus, or may choose to address in-depth one or a few elements, encompassing a much shorter time frame. For example, a biology teacher may elect to study human energy and nutrient needs in the context of the Mars project, requiring students to design a feasible and adequate diet under likely mission constraints. This could encompass a month of work in an introductory or even advanced biology class. Or, a studio art class may decide to use the concept of space as an organizer for an entire semester or year's work, studying space in various artists' work and having students create a portfolio of original artwork.

g. Even if you are the only teacher doing the project, who might you involve as an outside assessor of student work to give the simulation more energy, credibility, or community involvement?

* The judges can be: the teacher alone, other teachers, students from other classes brought into

the simulation by their teacher(s), and/or adults from the community (including those who work in the relevant fields). Whoever judges needs to have the rubrics for judging the proposal and the presentation; you as teacher will most likely be the sole judge of the group planning and process (using the Process rubric).

h. What will be assessed and graded, above and beyond the written proposal, presentation to the judges, and group process (with help from the 3 rubrics provided for each of these tasks)? We have suggested a few science labs and tests, and additional research papers.

Using the Materials to Suit Your Needs

Whatever you decide in the way of project scope, you will need to edit or revise the student task and other materials for the project to reflect the decisions you have made about how much work will be done, on what time-table, and in what way.

The last two scenes are optional, and all of the scenes could be collapsed into one or two. You need only make sure that students know their commitments before the simulation begins.

Though this project is intended as an inquiry-based exercise, for varying reasons (limits on available time, expertise, resources, student background knowledge, etc.) you might turn some of the scenes (or stages within each scene) to brief direct-teaching classes or provide written answers or narratives of results to move the project forward in a timely fashion.

In case either the students or the teacher feel uncomfortable with immediate entry into inquiry-based work where there is minimal adult direction and upfront teaching, a hybrid approach of directed teaching and scaffolded inquiry may make the best sense. Here, the teacher might carefully direct all students through one of the core topics at the beginning to model/practice inquiry-based learning, and then divide students up into expert research groups to work on the remaining topics. (For information on how to set up a jigsaw for these units, please consult the jigsaw diagram and notes.)

Unit Title: Mars: Survival and Beyond
Grade Level: 9-12
Subject Areas: Biology, Chemistry, Physics, Earth Sciences, the arts, and social science

Link to National Content Standards:

A teacher devoting an academic year of student focus using this problem-based curriculum will address the following content standards depending on the depth of topic coverage (the standards are from The Mid-Continent Regional Educational Laboratory (McREL) Compendium of Standards. (www.mcrel.org - Standards.)

Language Arts Standards - Writing
* Demonstrates competence in the general skills and strategies of the writing process
* Gathers and uses information for research purposes

Visual Arts Standards
* Understands and applies media, techniques, and processes related to the visual arts
* Knows a range of subject matter, symbols, and potential ideas in the visual arts
* Knows ways in which various arts media can be integrated
* Knows how to use the structures (e.g., sensory qualities, organizational principals, expressive features) and functions of art

Music Standards
* Knows and applies appropriate criteria to music and music performances
* Understands the relationship between music and history and culture

Theater Standards
* Understands how informal and formal theater, film, television, and electronic media productions create and communicate meaning

Health Standards
* Knows environmental and external factors that affect individual and community health
* Knows how to maintain mental and emotional health

Behavioral Studies Standards
* Understands various meanings of social group, general implications of group membership, and different ways that groups function
* Understands conflict, cooperation, and interdependence among individuals, groups, and institutions

Thinking and Reasoning Standards
* Applies decision-making techniques

General Science Standards
* Understands basic features of the Earth
* Understands basic Earth processes
* Understands essential ideas about the composition and structure of the universe and the Earth's place in it
* Knows about the diversity and unity that characterize life
* Knows the general structure and functions of cells in organisms
* Understands how species depend on one another and on the environment for survival
* Understands the cycling of matter and flow of energy through the living environment
* Understands the basic concepts of the evolution of species
* Understands basic concepts about the structure and properties of matter
* Understands energy types, sources, and conversions, and their relationship to heat and temperature
* Knows the kinds of forces that exist between objects and within atoms
* Understands the nature of scientific knowledge
* Understands the nature of scientific inquiry

* Understands the scientific enterprise

Specific Standards

Earth Sciences

Knows the major external and internal sources of energy on Earth (e.g., the sun is the major external source of energy; the decay of radioactive isotopes and gravitational energy from the Earth's original formation are primary sources of internal energy)

Knows that weather and climate involve the transfer of energy in and out of the atmosphere

Knows how winds and ocean currents are produced on the Earth's surface (e.g., effects of unequal heating of the Earth's land masses, oceans, and air by the Sun; effects of gravitational forces acting on layers of different temperatures and densities in the oceans and air; effects of the rotation of the Earth)

Knows how life is adapted to conditions on the Earth (e.g., force of gravity that enables the planet to retain an adequate atmosphere, intensity of radiation from the Sun that allows water to cycle between liquid and vapor)

Knows that elements exist in fixed amounts and move through the solid Earth, oceans, atmosphere, and living things as part of geochemical cycles (e.g., carbon cycle, nitrogen cycle)

Knows that throughout the rock cycle (e.g., formation, weathering, sedimentation, reformation), the total amount of material stays the same as its form changes

Understands the concept of plate tectonics (e.g., the outward transfer of the Earth's internal heat and the action of gravitational forces on regions of different density drive convection circulation in the mantle; these convection currents propel the Earth's crustal plates, which move very slowly, pressing against one another in some places and pulling apart in other places)

Knows effects of the movement of crustal plates (e.g., earthquakes occur along boundaries between colliding plates; sea floor spreading occurs where plates are moving apart; mountain building occurs where plates are moving together; volcanic eruptions release pressure created by molten rock beneath the Earth's surface)

Knows methods used to estimate geologic time (e.g., observing rock sequences and using fossils to correlate the sequences at various locations; using the known decay rates of radioactive isotopes present in rock to measure the time since the rock was formed)

Knows how the evolution of life on Earth has changed the composition of the Earth's atmosphere through time (e.g., one-celled forms of life emerged more than 3.5 billion years ago; evolution of photosynthesizing organisms produced most of the oxygen in the modern atmosphere)

Biology

Knows how variation of organisms within a species increases the chance of survival of the species, and how the great diversity of species on Earth increases the chance of survival of life in the event of major global changes

Knows the structures of different types of cell parts (e.g., cell wall; cell membrane; cytoplasm; cell organelles such as the nucleus, chloroplast, mitochondrion, Golgi apparatus, vacuole) and the functions they perform (e.g., transport of materials, storage of genetic information, photosynthesis and respiration, synthesis of new molecules, waste disposal)

Understands the chemical reactions involved in cell functions (e.g., food molecules taken into cells are broken down to provide the chemical constituents needed to synthesize other molecules; enzymes facilitate the breakdown and synthesis of molecules)

Knows how the interrelationships and interdependencies among organisms generate stable ecosystems that fluctuate around a state of rough equilibrium for hundreds or thousands of years (e.g., growth of a population is held in check by environmental factors such as depletion of food or nesting sites, increased loss due to larger numbers of predators or parasites)

Knows that as matter and energy flow through different levels of organization in living systems and between living systems and the physical environment, chemical elements (e.g., carbon, nitrogen) are recombined in different ways

Knows that because all matter tends toward more disorganized states, living systems require a continuous input of energy to maintain their chemical and physical organizations

Understands how the processes of photosynthesis and respiration in plants transfer energy from the Sun to living systems (e.g., chloroplasts in plant cells use energy from sunlight to combine molecules of carbon dioxide and water into complex, energy-rich organic compounds, and release oxygen to the environment)

Knows that the complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism

Knows how the amount of life an environment can support is limited by the availability of matter and energy and the ability of the ecosystem to recycle materials

Knows that heritable characteristics, which can be biochemical and anatomical, largely determine what capabilities an organism will have, how it will behave, and how likely it is to survive and reproduce

Knows that natural selection leads to organisms that are well suited for survival in particular environments, so that when an environment changes, some inherited characteristics become more or less advantageous or neutral, and chance alone can result in characteristics having no survival or reproductive value

Knows how natural selection and its evolutionary consequences provide a scientific explanation for the diversity and unity of past and present life forms on Earth (e.g., recurring patterns of relationship exist throughout the fossil record; molecular similarities exist among the diverse species of living organisms; the millions of different species living today appear to be related by descent from common ancestors)

Knows that the basic idea of evolution is that the Earth's present-day life forms have evolved from earlier, distinctly different species as a consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring

Knows the history of the origin and evolution of life on Earth (e.g., life on Earth is thought to have begun 3.5 4 billion years ago as simple, one-celled organisms; during the first two billion years, only microorganisms existed; after cells with nuclei developed about a billion years ago, increasingly complex multicellular organisms evolved)

Chemistry

Understands how elements are arranged in the periodic table, and how this arrangement shows repeating patterns among elements with similar properties (e.g., numbers of protons, neutrons, and electrons; relation between atomic number and atomic mass)

Knows that the physical properties of a compound are determined by its molecular structure (e.g., constituent atoms, distances and angles between them) and the interactions among these molecules

Knows the structure of an atom (e.g., negative electrons occupy most of the space in the atom; neutrons and positive protons make up the nucleus of the atom; protons and neutrons are almost two thousand times heavier than an electron; the electric force between the nucleus and electrons holds the atom together)

Knows how radioactive isotopes can be used to estimate the age of materials that contain them because radioactive isotopes undergo spontaneous nuclear reactions and emit particles and/or wavelike radiation; the decay of any one nucleus cannot be predicted, but a large group of identical nuclei decay at a predictable rate, which can be used to estimate the material's age

Knows that chemical reactions can take place at vastly different rates (e.g., from the few femtoseconds required for an atom to move a fraction of a chemical bond distance to geologic time scales of billions of years), and reaction rates depend on a variety of factors (e.g., how often the reacting atoms and molecules encounter one another; temperature; properties, including shape, of the reacting species)

Knows that chemical reactions can be accelerated by catalysts (e.g., some chemical reactions may be catalyzed by metal surfaces; chemical reactions in living systems are often catalyzed by protein molecules called enzymes)

Knows the variety of structures that may be formed from the bonding of carbon atoms (e.g., synthetic polymers, oils, the large molecules essential to life) and their roles in various chemical reactions, including those required for life processes

Knows that a large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions, molecules, or atoms

Understands radical reactions and their role in natural and human processes (e.g., ozone and green house gases in the atmosphere; burning and processing of fossil fuels; formation of polymers; explosions)

Knows that although the total energy of the universe remains constant, matter tends to become steadily less ordered as various energy transfers occur (e.g., by collisions in chemical and nuclear reactions, by light waves and other radiations), and the energy tends to spread out uniformly

Knows that all energy can be considered to be either kinetic energy (energy of motion), potential energy (depends on relative position), or energy contained by a field (electromagnetic waves) Understands the relationship between heat and temperature (heat energy consists of the random motion and vibrations of atoms, molecules, and ions; the higher the temperature, the greater the atomic or molecular motion)

Understands that chemical reactions either release or consume energy (i.e., some changes of atomic or molecular configuration require an input of energy; others release energy)

Knows how the energy associated with individual atoms and molecules can be used to identify the substances they comprise; each kind of atom or molecule can gain or lose energy only in particular discrete amounts, and thus can absorb and emit light only at wavelengths corresponding to these amounts

Physics

Knows the range of the electromagnetic spectrum (e.g., radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, x-rays, gamma rays); electromagnetic waves result when a charged object is accelerated or decelerated, and the energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength

Knows that apparent changes in wavelength can provide information about changes in motion because the observed wavelength of a wave depends upon the relative motion of the source and the observer; if either the source or observer is moving toward the other, the observed wavelength is shorter; if either is moving away, the wavelength is longer

Understands general concepts related to the theory of special relativity (e.g., in contrast to other moving things, the speed of light is the same for all observers, no matter how they or the light source happen to be moving; nothing can travel faster than the speed of light)

Knows that laws of motion can be used to determine the effects of forces on the motion of objects (e.g., objects change their motion only when a net force is applied; whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object; the magnitude of the change in motion can be calculated using the relationship F=ma, which is independent of the nature of the force)

Knows that electromagnetic forces exist within and between atoms (e.g., electric forces between oppositely charged electrons and protons hold atoms and molecules together, and are involved in all chemical reactions; electric forces hold solid and liquid materials together and act between objects when they are in contact)

Knows that the strength of the gravitational force between two masses is proportional to the masses and inversely proportional to the square of the distance between them

Knows that scientific explanations must meet certain criteria to be considered valid (e.g., they must be consistent with experimental and observational evidence about nature, make accurate predictions about systems being studied, be logical, respect the rules of evidence, be open to criticism, report methods and procedures, make a commitment to making knowledge public)

Designs and conducts scientific investigations by formulating testable hypotheses, identifying and clarifying the method, controls, and variables; organizing and displaying data; revising methods and explanations; presenting the results; and receiving critical response from others

Knows that conceptual principles and knowledge guide scientific inquiries; historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists

Understands that individuals and teams contribute to science and engineering at different levels of complexity (e.g., an individual may conduct basic field studies; hundreds of people may work together on a major scientific question or technological problem)

Understands that science involves different types of work in many different disciplines (e.g., scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations; many scientific investigations require the contributions of individuals from different disciplines; new disciplines of science, such as geophysics and biochemistry, often emerge at the interface of older disciplines)

Knows that creativity, imagination, and a good knowledge base are all required in the work of science and engineering.

Brief Summary of the unit:

In this inquiry-based unit, students will participate in teams as part of a competition for designing a colony on Mars that meets the colonists physical and aesthetic needs. The science research team for the Mars 2030 Project is responsible for identifying the basic life support needs of the colonists, identifying elements of the Martian environment that will challenge the meeting of these life support needs, and designing and siting a suitable and sustainable habitat on Mars for 100 people. The social science research team for the Mars 2030 project must consider the welfare of participants. Designers must grapple with the issues surrounding both the selection of participants and their continued welfare; it is easy for designers to underestimate the importance of interpersonal issues (communication skills, language and cultural differences), yet these are certain to pose significant challenges to the community on Mars 2030. The art team must consider the literal and metaphorical meaning of the word "space." Team members will develop artworks reflecting concepts of space that may include qualities that range from real to imagined, 2-dimensional to 3-dimensional, functional to whimsical, and models to actual spaces. The art research team will research ways that different artists use and organize space inl images to determine factors that influence artistic decisions and the communication of concepts of space. They will use this knowledge to design a livable space for the Mars colonists, and to design a legacy gallery for future generations to come to know the colonists of 2030.

As a result of this unit, students will understand:

* Life requires essential material and energy inputs and elimination of unneeded outputs.
* Assuring the physical well-being of participants in Mars 2030 Project demands careful consideration and planning of multiple life support needs: adequate food and water; proper atmosphere (composition, temperature, humidity, and pressure); and efficient elimination and/or recycling of wastes.
* Life depends on the physical world and must function within limits set by physical laws.
* Differences between the physical environments of Mars and Earth (for example, atmospheric composition, temperature, radiation, pressure, gravity, availability of water and organic matter) will provide the 2030 colonists with challenging constraints and opportunities in designing and creating a sustainable Martian living environment.
* Cultural values and beliefs and social and emotional conditions are strong influences on visual expressions.
* Artists select and use visual elements and materials to communicate ideas that comment on social concerns, express moods and feelings, and communicate imagined or real worlds.
* Artists experiment with materials to identify processes, techniques, and media to effectively communicate ideas.
* Space has many connotations which influence the manner in which artists choose to interpret it.
* Artists learn by studying the work of other artists. The analysis of artworks requires the viewer to identify literal, visual, and expressive qualities in the work.
* Knowledge of structures and functions are critical to developing effective visual compositions.
* Artists use "thumbnail sketching" and 3-dimensional mock-up as a process for thinking and developing ideas.
* Artists experiment with materials, processes, and techniques to understand ways of using media to express ideas.

* Each medium and technique has unique characteristics.
* Successful artistic work requires periodic assessment of progress.
* Confined, isolated Earth-bound communities (submarines, remote military outposts, Antarctica stations, polar expeditions, sequestered juries) offer evidence to help designers anticipate participant responses to life in Mars 2030.

Essential questions guiding this unit:

*What are the minimal material and energy requirements necessary to sustain life?
* What physical factors support life on Earth and are likely to exist or not exist on Mars?
* What role do the arts and communication play in successful colonizing and culture-building?
* What social skills will minimize conflict and facilitate the colonists living together in harmony?

Student Assessment in the unit:

Following their research in expert groups, students will design proposals based on their area of expertise. Proposal teams will present their designs. Following the culmination of project proposals, students will each be required to critique the design proposals of their peer experts.

To the students:

You are a member of a small research team on colonizing the planets. There are several teams working on these issues. Each team's task is to propose the design and site of a proposed Mars colony, slated to begin in 2030. Your design must address all the core questions related to human physical and interpersonal well-being.

To develop the best proposal for this vital and high-profile project, a two-part process has been developed: an internal friendly competition followed by a collection of the best ideas into one proposal. After an internal review and judging of each of the team proposals, all the teams working together will adapt ideas from each proposal to fashion the best overall design. That single proposal will then be developed and presented to the Mars Millennium national registry and gallery.

Both the preliminary small-team internal competition and the single overall proposal will be judged against various criteria and guidelines. There are scoring guides for your proposal and your presentation (with additional guidelines for the group process). The proposal must be: comprehensive in terms of research/and or design work on the key issues; scientifically accurate, supported by credible data and argument; and mindful of various sensitive cultural, political, and moral issues. The presentation must be polished and persuasive, making use of multimedia, 3-D models, artwork, and appropriate handouts. The process requires the team to plan effectively and work well as a team in addition to the production of individual work.

The project first calls for each of you in pairs to become experts in one topic. Your pair will develop that topic as part of your team's overall proposal. You will also break out into expert topic study groups, working with members from other teams who are working on that same topic (see Jigsaw guidelines). This mix of friendly competition and collaboration ensures the most rich and effective collection of ideas for the single final proposal.

In addition to the criteria and guidelines for self-assessing and judging the team's work, you will use a research planning tool-a decision matrix- for helping with the most effective data-gathering and team decision-making. The decision matrix needs to be filled out as you work in design teams and expert areas.

The unfolding experience takes place through different scenes, described below. (Note that in the interest of time, your teacher may not elect to do one or more scenes).

Scene I

Teams are formed and named, members choose the topic they are interested in, and the internal competition gets underway. (See the stages of the Scene I jigsaw for further information). Team proposals are judged using the scoring guidelines for proposal, presentation, and process. Judges will consider each team's proposed colony.

Proposal guidelines:

Not to exceed 50 total pages
A final report integrating the research/design work into all topics
An explanatory narrative on the decisions made via the Decision Matrix and the judgments made about which criteria to honor and why
A background Appendix with each team member's research papers
A 3-D and/or 2-D model of what the colony will actually look like
An Executive Summary (not to exceed three pages) highlighting the proposal

Scene II

Having agreed upon the best of the team proposals, all the teams must now formulate a single proposal adding any features of other proposals to the winning proposal the whole class chooses to include. This final proposal is then ready for consideration by the Mars National Registry and Gallery.

Scene III

After the vote, the challenge is to interest the American public in the proposed colony. You are now in the business of marketing and public relations. Each of the original (or new) design teams must now formulate a sophisticated public relations campaign to promote the overall NASA proposal. Using whatever artistic media you think appropriate, develop a compelling brochure to be mailed to key government officials; and print ads and video commercials to be published in newspapers and aired on TV.

The Art Team Task

Design teams can be established for the arts (and sub-divided as needed into art forms or areas of the colony). Essential to the success of the Mars mission is a wise and aesthetically pleasing use of the human space to be inhabited. Whether we consider the long journey to the Red Planet in capsules or life in the colony once there, the challenge is to ensure that the space is well-designed and satisfying - functionally and artistically.

In addition to design for living, there is the issue of the legacy of the colony. With the likelihood that the colony's artifacts will remain for centuries, there is a need to establish a permanent record about the inhabitants for any would-be curious visitors - including, perhaps, one day from other galaxies.

In this design challenge, your team must consider how to best humanize, personalize and beautify the relatively small and simple spaces to be inhabited. Both living quarters and common spaces will need artwork. Your proposal, to include sample designs and artifacts, will be judged in terms of the appropriateness of the design for the location and the polish of the models and written proposal.

In addition, as part of the artistic use of common space in the colony, you must propose a small gallery collection of photographs/images/music/artifacts to provide an answer to the question: "Who were these people?" The question is to be understood as addressing the particulars (you and members of your design team) and humankind (how might we represent who we are as a species, what is most human about us). Your proposed gallery about Earth's inhabitants and their culture should encompass no more than 30 photographs/images/music pieces/artifacts and represent a thoughtful and revealing image of humanity. As part of your research, you should review the materials launched with Pioneer to see what a previous generation of space scientists thought fitting as a record of humankind to send into space (See Murmurs of Earth: The Voyager Interstellar Record by Carl Sagan et al.).

2. Presentation: All design teams will present their proposals (see rubric).

3. Oral critique: Following the project proposals and presentations, students will be required to critique the design proposals of one of their peer experts.

Rubrics for Judging Student Work

MARS 2030: Proposal Persuasiveness

6 The proposal is unusually imaginative, well-documented, and plausible. The research is rigorous, and supporting documentation and analysis are thorough and insightful. The conclusions and proposed solutions to the various design issues and problems are credible and creative. Complex ideas have been well thought through, using sophisticated techniques/tools/concepts. The design criteria have been thoughtfully considered and effectively addressed. This is an unusually sophisticated, complete, and high-quality proposal.

5 The proposal is sound and plausible. The ideas are well-researched, and supporting

documentation and analysis are thorough. The conclusions and proposed solutions to the various design issues and problems are credible. Complex ideas have been well thought through using complex techniques. The various design criteria have been thoughtfully considered and addressed. This is a strong, complete, and well-grounded proposal.

4 The proposal is sound. The research is thorough, and adequate documentation has been provided. The conclusions and proposed solutions to the various design issues and problems are mostly credible and creative (with perhaps an imbalance one way or the other). Important ideas have been well thought through, though the techniques/tools/concepts used may not be as sophisticated as those used by the best proposals. The various design criteria have been considered and addressed. This is a thorough and interesting proposal.

3 The proposal is adequate. The data are reasonably clear and appropriate, but there may be important inadequacies or errors in the research. There may be errors or oversights in data, calculations, formulae, and/or models used that detract from the proposal. Some important issues have been thought through, but not all, and/or the techniques/tools/concepts used were somewhat simplistic or crude. Most of the design criteria have been considered and addressed and/or all were considered but the final proposal does not adequately address them. This is an interesting but flawed or incomplete proposal.

2 The proposal is incomplete or flawed. The research and data are not convincing as presented, due to incompleteness, superficiality, and/or inappropriate resources. Key issues and design criteria may have been ignored or given short shrift. Techniques/tools/ concepts used may have been very simplistic. This is an inadequate proposal, even if it contains many thoughtful ideas.

1 The proposal is deficient in research, documentation, and analysis. Either the students did not understand the task, understand the research required, understand the information; and/or there was little attempt to meet the obligations of the proposal. This is an unacceptable proposal.

MARS 2030: Quality of the Planning and Research Process

4 The team's approach was methodical, efficient, and effective. They carefully developed and smoothly carried out a sound plan for gathering information, assigning roles, using each other's talents and interests, addressing the problem(s) required, and pulling all work together for the proposal. The team was unusually effective in dividing up areas of responsibility and then pulling together individual research and points of view into a coherent proposal that could be owned by all members. Each member pulled his or her weight. The attention to process and planning resulted in minimal conflicts, maximal productivity, and a fair division of labor.

3 The team's approach was methodical overall, although there may have been a few avoidable inefficiencies. There was a clear and agreed-upon plan for information gathering, dividing up roles and responsibilities intelligently, and for pulling together findings and ideas. All members seemed productive as a result. Even if there were gaps or inadequacies in the plan, problems that arose en route were quickly and decisively addressed. There may have been minor inefficiencies

or lapses in group effectiveness or cohesiveness, but the group effectively worked through these difficulties. In general, the team members worked well together and did their fair share, even if there were lapses in teamwork (due either to a lack of planning or of group-process skills).

2 The team's approach was somewhat unmethodical and inefficient. There was evidence of prior planning and division of labor, but one or both were not fully thought through, leading to a variety of process problems and wasted time en route. There may have been a failure to think through division of labors, the scope of the work, and a final plan for bringing all the individual work together to ensure a quality proposal and/or there were unequal efforts put forth by team members and the inequities were not addressed by the team and/or the team did not function smoothly and attempts to solve process problems were ineffective. The absence of planning and attention to roles and responsibilities may have led to some of these arguments and frustrations in accomplishing the task.

1 The team's process was both inefficient and ineffective in accomplishing the task. They failed to develop an adequate plan and strategy for finding information and solving the problems; and/or they failed to handle maturely the group process issues that arose. One or more team members may not have done their fair share, and no adequate plan or response was made to grapple with the problem.

Note: this rubric refers only to the research process, not the final accuracy and completeness of the research used in the final proposal.

MARS 2030: Quality of Presentation

6 The overall presentation is highly convincing. The team's work is presented clearly and with poise. The facts, arguments, and conclusions provided are very persuasive. The presentation is mindful of purpose, audience and context, as reflected in the content and delivery of remarks and responses to questions, and the overall tenor of the performance. The presentation is thorough and logical without being overwhelming or incomplete. There is obvious craftsmanship and attention to detail in the prepared materials: good use is made of polished and effective models; the PowerPoint slide show, if used, contains apt summary arguments and data in helpful diagrams, graphs, and charts. Language is appropriate and helpful- technical and accurate when needed, but succinct and straightforward when needed. Minor errors in delivery, grammar, spelling, etc., if they occur, do not distract. This is a sophisticated and unusually effective set of performances and products.

5 The overall presentation is convincing. The team's work is presented clearly and smoothly. The supporting research is thorough and thoughtful. The key ideas, facts and arguments provided are to the point, well explained, and persuasive. Audience and purpose have been taken into account with perhaps minor lapses. The presentation is thorough and logical. There are helpful models and slides with diagrams, graphs, and charts. Language is appropriate; minor errors, if they occur, do not distract. This is a polished set of performances and products.

4 The overall presentation is effective. The team's work is presented in a clear and

reasonably smooth way. Content and delivery suggests that the students were mindful of purpose and audience, but there may be a few lapses into views that reflect personal interests only. There may be a few gaps or inadequacies in some of the research and ideas presented, but overall the key problems have been researched and well thought through. Supporting visuals and models are generally appropriate and useful, but with perhaps variance in style/clarity/accuracy/completeness. Language and style are appropriate but not always sufficiently precise or developed. Errors in delivery, mechanics, etc., do not interfere with the overall clarity and fluency of the work but may distract in places. This is overall a well-developed and plausible account.

3 The overall presentation is somewhat effective. The team's work is presented in an adequate way, but there may be awkwardness or errors in delivery and/or gaps in content that suggest a lack of preparation (and/or weaknesses in the overall research and proposal). The audience and purpose are addressed, though there may be lapses- a focus on students' personal interests instead of those of the audience's and the project's needs. There may be gaps or errors in some of the research and ideas presented; many but not all of the key issues have been researched and thought through. Models and supporting material may be appropriate but not perhaps always clear, precise, or otherwise helpful. Language in the materials may be adequate but perhaps not always well-suited or refined enough to meet the demands of the challenge. Errors in mechanics or spelling may somewhat negatively impact the presentation. Key ideas may be insufficiently developed, justified, or explained. The presentation is acceptable but not indicative of either great control over all the technical issues and arguments and/or refinement of methods of presentation.

2 There are weaknesses in the overall presentation. The team_s work suggests either a lack of adequate planning and rehearsal and/or a failure to develop an adequate complete proposal. Audience and purpose may often be ignored: The performance may be wooden, too brief, or perfunctory. There may be major errors in the prose (sentence structure, usage, mechanics or spelling) that interfere with the fluency and impact of the ideas. There may be key places where ideas are not well supported, clarified, or developed. Language may be too imprecise, inappropriate, or simplistic to convey the intended ideas. Errors in mechanics or spelling may often negatively impact the presentation. Key ideas may be insufficiently developed, justified, explained, or worked through as a team. Or the work suggests an overall lack of care and follow-through. This is an unconvincing set of performances and products, even if done in good faith.

1 The presentation is unpolished and ineffective. The performance suggests that either the students did not understand the task, the research required, and the information they presented, and/or there was little deliberate attempt to meet the obligations of the task in a disciplined and purposeful way. The presentation is incomplete and unrefined and/or filled with significant inaccuracies or gaps in content. There is little or no evidence of craftsmanship and polish. This is an unacceptable performance.

Teaching and Learning Experiences for the Art Team:

1. Divide the class based on individual interest into groups to explore various artistic media for use in the spaceship and the colony on Mars.

2. Students will report back to the whole class on their preliminary ideas, and a jigsaw of small design teams will develop the final proposal. (See the Jigsaw Figure for a visual representation of these stages.) These stages can be altered, collapsed or re-arranged to suit the teacher's curriculum or interests. Stages 1 and 2 are especially designed for group research on different topics, including the need for agreement on the 30+ images, sounds, and artifacts to include in the Colony Gallery.

Stage 1: You may wish to do some group design brainstorming first. If so, divide the class into proposal teams of up to 4 members each. Each team member will be assigned to one of the four topic groups in order to develop expertise in one of the core areas (Aesthetics of spaceship; aesthetics of colony; needs of artists and non-artists in the colony; the form and content of the Colony Gallery on "Who We Are."

Stage 2: The expert groups will work together to develop multiple designs and gather as much information as possible on the topic they're investigating. At this point, the teacher can provide as many (or as few) resources/ suggestions/questions as s/he wishes, knowing that effective inquiry takes both time and coaching. Some research questions the groups might consider:

Topic Question: What role will art and aesthetics play in the welfare of colonists?
Specific questions:
Dr. Norman Thagard, considering the future for long term space flight following 115 days on board SkyLab III, stated: "Psychological issues loom longest." How might aesthetic planning address these issues?
What rituals should be transported to Mars? devised there?
What resources on Mars might be found to supply artists with raw materials? What minimal resources for the arts must be transported to the colony?
Which projects can you envision that would allow colonists to use recycled or renewable resources in the process of creating art?
Where and how will colonists' creations (and photo gallery about earth) be viewed?
What role can technology play in shaping the physical and creative process?
How might images from home be chosen, taken, and displayed?
What do we mean by space? What are various concepts of space? How do concepts of space influence artistic interpretations?
What factors might influence decisions to use and organize space in a particular way?
How do cultural values and beliefs and social and emotional factors influence artistic decisions?
How do artists use materials, techniques, and processes to communicate ideas?

Stage 3: (This stage can be the first stage for teachers wishing only to concentrate on student individual designs). Each individual student or topic pair should be allowed time to develop design proposals (their own expert piece of the puzzle in Stages 1 and 2 or their own individual interests) to share with their proposal team and with the teacher for any individual assessment.

Stage 4: The class will come together to collaboratively consider and complete the Mars 2030 Decision Matrix: Arts Focus as a way to raise students' awareness of the underlying assumptions and the inevitable costs of any design decision. (Even if the students are working alone on design projects, this project should be done in terms of the Colony Gallery and/or some of the emerging individual design ideas.)

Stage 5: Students will reunite with their proposal team members (Stages 1 and 2) to present their own expert findings and to collectively generate a list of specific recommendations for the colony.

Stage 6: Proposal teams (or individual designers) will present their design proposals. Students should be expected to prepare mock-ups of the part of the work for which they are responsible. Design solutions must carefully consider the relationship between form and function.

Stage 7: Students will critique the proposals of one of their peer experts, thereby allowing the teacher to assess the student's level of understanding of the artistic and design principles to be understood.

Before they begin their work, students will discuss with the teacher the scoring rubrics for process, proposal, and presentations so that they may begin to understand their role in the proposal team, and the expectations for the work that they will do as a team.

Teaching and Learning Experiences for the Science and Social Science Teams:

Because this unit is designed as inquiry-based, it is organized around a set of research questions for each group of student/researchers to tackle. The questions can be provided to students up front or students can derive them through brainstorming and gaps then filled by the teacher. The lists are not meant to be exhaustive but simply suggestive as a place to begin. To get started, it will be important to explicitly state and clearly articulate the initial premises and constraints of the mission in order to provide a realistic context. For example, what technology, life support, and habitat resources will initially be consumables-based (via resupply from Earth) and what, if any, will be based on local materials and manufacture? How much, if any, terraforming (i.e., planetary engineering) will be planned? Next, it will be important to determine how much time will be devoted to the Mars 2030 curriculum and what subject areas listed in the focus questions below are relevant to your curriculum. If a short amount of time is available, then choosing a discrete and well-defined topic area will work best. For example, the atmosphere portion of the focus questions will provide a wide variety of short but fruitful inquiry areas that would be appropriate to an introductory chemistry course (see the ChemCom or Chemistry in Context resources).

Timing and Possible Lesson Outlines for the Unit

If a teacher feels s/he has only a week to devote to the research on the science topics, then it would make sense to set up a jigsaw and provide students with guiding questions and a couple of key resources. In this way students could quickly access and process critical information without spending time locating sources. Once expert groups had mastered the necessary material, proposal teams would form and each of the experts would advise their team on issues relating to his/her topic. The research would culminate with team proposal presentations to the class. If a teacher has more time, students can delve more deeply and focus more on process. Given a month, teachers might prefer to spend the first few days working through one core topic as a whole class with ready access to both questions and resources. The class could then be divided into expert groups to investigate the remaining core topics. In this case as well the teacher would probably wish to jump start the students' inquiry by providing guiding questions and some key resources. When the expert groups had gained a handle on their topics, then the proposal teams would form and begin work on their proposal. This would allow fairly scaffolded student-centered learning and the opportunity for students to develop expertise in more core areas. Given a full term or year, a teacher might very well want to remove nearly all supports in order for the students to engage more fully in an authentic problem-based learning experience. While in this case the role of the teacher remains crucial, s/he is no longer viewed as the repository for information and serves rather as a coach to her/his students, asking questions, suggesting possible resources, providing feedback on process. The core topics could be dealt with sequentially or simultaneously (using a jigsaw approach). In the case of a full month or year, there would be time to focus more on decision making strategies using the Mars 2030 Decision Matrix and on team planning and research using the Mars 2030: Quality of the Planning and Research Process rubric. Team proposals take on real importance and could be presented to a larger community that could serve as officials evaluating proposals. A rubric, Mars 2030: Proposal Persuasiveness can be used to guide preparation as well as to evaluate presentations of proposals by teams.

What follows is an outline for a course using a jigsaw approach with more than a month to dedicate to the expert research and team proposal development; of course teachers may wish to make major changes to adapt the lesson plans to better meet students' needs.

To set the stage for the unit:

1. Brainstorm with students about Earth-bound environments analogous to Mars 2030, generating a complex Venn diagram which isolates the characteristics of confined, isolated communities (submarines, remote military outposts, Antarctica stations, polar expeditions, sequestered juries); brainstorm about probable ways individuals/groups might respond to such environmental extremes.

2. Divide the class based on individual interest into groups that will look into experiences of individuals in comparable Earth-bound habitats (submarines, remote military outposts, Antarctica stations, polar expeditions, sequestered juries) that might offer insight into the life on Mars 2030; Bold Adventures (see resources list for ordering information) would serve as a source of information; students might also want to look at Internet sites (see resources list) as well; this will only take a couple of days.

3. The research and proposal generation process is divided up into stages. See the Jigsaw Figure and notes for further information.

Stage 1: Divide class into proposal teams of 10 members each. Each team member will be assigned to one of the topic groups in order to develop expertise in one of the topic areas.

Stage 2: The expert groups will work together to gather as much information as possible on the topic they're investigating. At this point, the teacher can provide as many (or as few) resources/ suggestions/questions as s/he wishes, knowing that effective inquiry takes both time and coaching.

Stage 3: When it becomes clear that the expert groups each have a good handle on the material, each individual student or team pair should be allowed time to work on his/her own to develop design proposals (their own expert piece of the puzzle) to share with his/her proposal team (and with the teacher for an individual assessment).

Stage 4: The class will then come together to collaboratively complete the Mars 2030 Decision Matrix as a way to raise students' awareness of the underlying assumptions and the inevitable costs of any design decision.

Stage 5: At this point students will reunite with their proposal team members to present their own expert findings and to collectively generate a list of specific recommendations for the design of the Mars colony to best assure the well-being of the community. Before they begin their work as a proposal team, the class will discuss the three scoring guidelines (rubrics) for the Mars 2030 project: Process, Proposal, Presentation, so that students may begin to understand their role in the proposal team, and the expectations for the work that they will do as a team. Proposal team members will be given time to think through the implications of that document for their team, and to begin to work out their roles, etc. Students will also work through the Mars 2030 Proposal Persuasiveness rubric to help focus their efforts as they begin to develop both a proposal and the presentation of that proposal.

Stage 6: Proposal teams will present their design proposals. Students should be expected to prepare both schematic plans and 3-D models of the station/features for which they are responsible. Design solutions must carefully consider the symbiotic relationship between form and function.

Stage 7: Students will critique the proposals of one of their peer experts, thereby allowing the teacher to assess the student's level of understanding in one of the core areas.

Research Topics and Questions (for life science, physical science, social science)

Life Sciences
Topic Question: What water needs and challenges will face the Mars colonists?
Specific Questions:
What are minimal human water requirements physiological needs, food preparation needs, hygiene needs (showers, laundry)?
How will water be recovered/recycled from various sources: human wastes (from sanitary and wash streams), food preparation, sweat, breath, gaseous?
What are ways to conserve water?
How will water be stored?
How will water be generated, if possible, from local resources?

What will be water quality standards for various uses (drinking, hygiene, grey water)what will be microbiological standards (coliforms), what will be physical standards (turbidity, color, taste, odor, temperature), what will be mineral content standards (hardness), what will be chemical standards (acidity, alkalinity, dissolved gases)?
How will water quality be monitored?

Topic Question: What food needs and challenges will face the Mars colonists?
Specific Questions:
What are human food energy needs (considering age, size, health, gender)?
What are human nutrient needs (considering age, size, health, gender)?
What dietary selection will provide the required energy and nutrient needs for humans given the likely resource constraints of a Martian colony?
What foods do people like to eat and what role should this play in dietary selection for the Mars colony?
What will plant growth facilities look like?
Will they have to be enclosed or can the local Martian environment be used for growing plants?
What is the Mars soil composition?
Can nutrients be added to make it suitable for growing plants?
Is there water available on Mars? where and in what form?
Can hydrogen and oxygen be extracted locally in some form for water production?
What Earth plants, if any, are capable of growing under drought and poor soil conditions?
Would they be suitable for the Martian environment?
What plants will provide maximal nutrition given the dietary needs identified?
What insects, soil organisms, bacteria, and other earth life will be necessary for growing crops?
What are candidate pioneer organisms for growth on Mars?
What organisms from extreme Earth environments might work?
What role would genetic engineering and genetic selection play in modifying likely Earth candidates for growth on Mars?
What role would pioneer organisms play in eventual planetary engineering (e.g. changing atmospheric composition, climate regulation, hydrological functions, soil formation, etc.)?
How will food be stored?
What will be food cultivation and preparation procedures?

Topic Question: What wastes will be produced by the Mars colonists and how will they be handled?
Specific Questions:
What solid wastes do humans produce physiologically (e.g., sweat solids, human wastes) and through daily maintenance activities (e.g., paper or plastic waste)?
What liquid wastes do humans produce physiologically (respiration/ perspiration water) and through daily maintenance activities (e.g., hygiene water, clothes wash water, food preparation)?
What gaseous wastes do humans produce (e.g. carbon dioxide)?
What are waste reduction strategies?
How will solid, liquid, and gaseous waste be recycled or disposed of?

Topic Question: What atmospheric needs and conditions will face the Mars colonists?

Specific Questions:
What living atmosphere needs and challenges will face the Mars colonists?
What are human requirements for oxygen?
What are human toxic limits for non-essential atmospheric gases (e.g. carbon dioxide, nitrogen, etc.)?
How will oxygen be generated or regenerated?
How will excess carbon dioxide be removed?
How and at what levels will nitrogen levels be controlled?
How and at what levels will trace gas contaminants be controlled?
How will airborne/dispersed microorganisms be controlled?
What will humidity levels be and how will it be controlled? What will be ambient temperature ranges and how will they be controlled?
What will be ambient pressure levels and how will they be controlled?
How will atmospheric gases be monitored?
Another focus of inquiry would revolve around the question: Is or was there life on Mars? Fruitful areas of investigation would involve evidence to be collected for current or past life on Mars, comparing Mars and Earth in terms of life-sustaining capability, or asking how the Martian environment would have to be altered to sustain life.

Physical Sciences
Topic Question: What is Marsmosphere?
Specific Questions:
What are the basic structural and compositional features of Martian atmosphere?
What dynamic forces have and are shaping Mars atmospheric composition?
What are temporal and geographic climatic patterns (especially temperature, solar radiation, and moisture)?
What is the Martian weather like on a daily or seasonal basis?
How do these patterns and forces compare to those on Earth?
What are more benign or less benign areas on Mars for sustaining life?

Topic Question: What is the Mars surface like?
Specific Questions:
What are the basic structural and compositional surficial features of Mars?
What dynamic forces have and are shaping Martian geologic features?
What are geographic surficial patterns on Mars?
How do these patterns and forces compare to those on Earth?
What are more benign or less benign areas on Mars for sustaining life?

Topic Question: What are Mars' energy resources?
Specific Questions:
What are energy sources on Mars?
What are the spatial/temporal patterns in levels of Martian energy sources?
What factors influence the spatial/temporal patterns in levels of Martian energy sources?
What energy sources on Mars are useable by current or projected technology?
How do these energy resources compare to those on Earth?

Topic Question: What are Mars' material resources?
Specific Questions:
What elements and molecules are found on Mars?
What are the spatial and temporal distribution of elements and molecules on Mars?
What factors influence the spatial/temporal patterns in levels of Martian elements and molecules?
How do these molecules react (or not) on Mars?
Which of these material resources might be useful to humans?
How do these material resources compare to those on Earth?

Social Sciences
Topic Question: Who should participate in Mars 2030?
To eventually arrive at a self-sustaining community of 100, how many participants should initially be transported, and what should their profiles be (in terms of gender, expertise, personality, race, nationality, marital status, age and genetic diversity)?
Should members have specialized skills and are there skills all should share?
Should couples/families be taken to Mars?
What gender mix makes sense and why?
What would a representative population look like, and is it desirable?

Topic Question: What should be done to assure that participants be able to communicate and relate effectively with one another?
Specific Questions:
Which language(s) will best facilitate effective communication between members of the community (lingua franca), given both linguistic and cultural considerations?
How does the language chosen influence the degree to which members interact?
How will language barriers be overcome, and what role might the arts play?
What can be done to assure that individuals adjust effectively to the isolation and confinement of Mars 2030 ?
Which psychological/personality traits best predispose an individual to functioning effectively under the conditions on Mars?
What form of government will allow colonists to live together in harmony?

Unit Resources

Labs and Student Activities

Examples of creative, hands-on, inquiry-based student activities related to life support in space can be found on the NASA Education Program and services Web site; activities for exploration of the Mars physical environment can be obtained through TERC's Mars Exploration Program curriculum; and activities for earth-based study of the physical environment as a way of comparing to Mars environments can be explored through the GLOBE Program. See the Resources section of this unit for access to these materials. Resources Printed Materials: Designing for Human Presence in Space: An Introduction to Environmental Control and Life Support Systems, NASA Reference Publication RP-1324detailed and technically-rich document aimed at all aspects of Controlled Ecological Life Support Systems (CELSS). Contains over 40 pages of life support and Martian references.Can be downloaded from a web site: [augusta.msfc.nasa.gov/ed61/papers/rp1324/rp1324.html]

TERC Mars Exploration Programa series of three Mars education modules. The hands-on, inquiry-based activities integrate Earth, physical, and planetary sciences and involve students in questions central to current Mars exploration. Write TERC/Mars, 2067 Massachusetts Avenue, Cambridge, MA 02140, 1-800-547-0430, fax: 617-349-3535 [http://web1.terc.edu]

Life Support and Habitability (Space Biology and Medicine) by F.M. Sulzman and A.M. A useful edited volume, technical in nature at times, providing an overview of life support needs involved with extraterrestrial travel and colonization. Available from Amazon.Com.

Mars Millennium Project: Educational Content Development Webs developed by David M. Seidel and Bruce Payne, Jet Propulsion Lab, (Educational Affairs Office, Mail Stop T-1709, 4800 Oak Grove Drive, Pasadena, CA 91109-8099, Fax (818-393-4977). Integrated science unit centered on site selection for an inhabited Mars base making use of NASA Educational Divisions graphical concept webs for thematically organizing educational materials. Materials developed make use of National Science Education Standards unifying concepts and processes to organize question series around the Martian colonization project. Invaluable resource.

The Case for Mars: The Plan to Settle the Red Planet and Why We Must by Robert Zubrin with Richard Wagner (Free Press). Zubrin writes voluminously about Mars colonization and his web page contains a number of useful links and printed information [www.nw.net/mars/marsdirect.html]. 12 Universities are involved in research on Mars colonization, supported by NASA, called Human Exploration and Development of Space-University Partners (HEDS-UP). The Cornell web site, for example, is at www.cs.cornell.edu/home/wkiri/hedsup.html.

Chemistry in the Community (high school level) and Chemistry in Context: Applying Chemistry to Society (college level)curricula by the American Chemical Society distributed (Wm. C Brown Publishers, Dubuque, IA). Developed to teach fundamental chemical concepts in the context of social, political, and economic issues with a problem-based and investigatory focus. The texts and lab books provide a wide variety of classroom and lab exercises centered around science/technology-related issues (global warming, water quality, nutrition, etc.) that would readily adapt to the problem-based approach of this Martian unit.

Web Sites:

Mars Academy, an educative collaborative project to design and simulate a manned mission to Mars. This web site contains a wealth of material covering life support systems, space medicine, and information about Mars. [www.marsacademy.com]

Advanced Life Support Program, NASA, Johnson Space Center web site that provides summaries and links to NASA Controlled Ecological Life Support Systems (CELSS)

Center for Mars Exploration, NASA contains a Mars atlas, maps, images, and a wide variety of educational resources for teachers. Useful source for gathering information about Martian environment. [cmex.www.arc.nasa.gov]

Astrobiology Web sponsored by Reston Communications, containing information and numerous web links to earth-based life in extreme environments, exobiology, life support systems related to planetary travel. See especially The Whole Mars Catalog and the Spacecraft Life Support Systems subsites. [www2.astrobiology.com/astro]

Controlled Ecological Life Support System (CELSS) Project, developed to provide the knowledge and understanding that is needed to develop the life support systems for use in long duration Lunar and Martian colonies. Out of NASA Ames Research Center. [brad.arc.nasa.gov/LSC.html]

Global Learning and Observations to Benefit the Environment (GLOBE), a worldwide network of students, teachers, and scientists working together to study and understand the global environment. Global images based on GLOBE student data are displayed on the World Wide Web, enabling students and other visitors to visualize the student environmental observations. [http://globe.fsl.noaa.gov]

NASA Education Programs Material, services, and teacher resources developed and compiled by NASA relevant to the space exploration [http://www.hq.nasa.gov/office/HR-Education/education/ed-prog.html]

For an overview of Bold Adventures by John Stuster visit:
[members.aol.com/jstuster/boldendeavors/book.htm]
Also try Stuster's Astronaut Quiz: determine how well suited you are to life on Mars:
[members.aol.com/jstuster/boldendeavors/quiz.htm]

Lindsey's Space Links: offers links to an enormous number of space pages, including many on space health: http://msia02.msi.se/~lindsey/spaceLinks.html

Human Factors, Office of Aeronautics, NASA-contains brief summaries of research done to better understand how human performance changes relative to environments, technologies, tasks and other people; see, for example, "Crew Performance in Space Analogous Environments" [www-afo.arc.nasa.gov/projects/crew-factors/space-analagous.html]

"Six Months on MIR" by veteran astronaut Shannon W. Lucid, published on the Web by Scientific American; Lucid reflects on her preparation for and stay on MIR, and implications for future international cooperation for space travel and research. [www/sciam.com/1998/0598issue/0598lucid.html#authors]

Printed Materials:

* Murmurs of Earth: The Voyager Interstellar Record, by Carl Sagan et al (Ballantine Publishing

1978). This book documents the background to the Voyager mission out of our solar system, focusing on the artwork and music representing earth's culture on board. A fascinating account of how astronomers pondered communicating to other beings who we are, and the jusitifcation for each image or sound chosen.

* Bold Adventures by John Stuster (available from Naval Institute Press, 1-800-233-8764) An indispensable reference for study of the psychology of the mission. Provides a wealth of information for thinking through issues of human adjustment and performance in long-term isolation. Topics include personnel selection, exercise, group interaction, recreation, privacy and the behavioral effects of isolation and confinement; Stuster offers specific suggestions to facilitate adjustment in future long-term space expeditions.

Narratives, Novels and Short Fiction

Into Thin Air by Jon Krakauer. A gripping, first person account of what lead to the worst tragedy Everest has ever seen.

Climb by Anatoli Boukreez. On the same expedition as Krakauer, different perspective.

The Fourth Man by John Russell. Short tale from a Canaque of New Caledonia. Three escapees from a penal colony and another man on a boat with limited water. Interesting, and frightening group dynamics.

Pitcairn's Island by Nordhoff and Hall. Post-mutiny (same trilogy as Mutiny on the Bounty), international group voluntarily stuck together on an island. Colony set up by Europeans and Tahitians; all the ingredients for a paradise, but it turns into a disaster.

Undaunted Courage by Stephen Ambrose. Study of the Lewis and Clark expedition.

<<insert jigsaw diagram here>>

Notes on the Jigsaw Plan

Before beginning any of the jigsaws, teachers must select the sub-unit(s) they will pursue (physical science, life science, arts, social science or any combination). The physical science unit will focus on atmosphere, surface, energy, and material resources; life science will focus on questions of water, food, waste, and atmosphere. In addition, there are various design challenges in the arts sub-unit and the social science sub-unit.

The overall structure of each of the sub- units comprises stages (see diagram):

Stage 1: Students are assigned to proposal teams of eight members each. Students then gather in expert groups to study one of the four core topics.

Stage 2: Students join with members from other teams who are researching their topic to form expert study groups and research their topic AND/OR create artistic designs and products.

Stage 3: Students each individually (or in team-topic pairs) write a set of design proposals based on their newly acquired expertise/artistic design ideas in one of the four topic areas.

Stage 4: As an entire class, students talk through the implications of the design decision matrix to grapple with the inherent dilemmas and trade-offs required in the design work. (The matrix may or may not have been given out by the teacher for work in Stages 2 and 3).

Stage 5: Reunited as proposal teams, students work to develop a set of design features that best satisfy the needs imposed by the information gathered in expert sub-groups and the implications of the decision matrix. Students will present their proposal to a panel.

Stage 6: Following the presentation of proposals, students will write a critique of the design proposals prepared by one or more of their peer topic experts.

<<insert decision matrix for sciences here>>

Notes on the Decision Matrix criteria for the sciences:

1. The simplest, minimal, least hassle, cheapest

The research focuses here on coming up with the answer involving the least hassle or expense. For example, under "language," the mission sponsors might simply declare, without any lengthy debate, that English is the mission language since it is one of the most common second languages learned, it is the language of international aeronautics, and it is the language of the sponsoring nation (even though such a decision might not meet the other criteria).

2. Optimal for overall community harmony and happiness

The research here focuses on coming up with answers that best support the meeting of the overall community's needs and interests. For example, "under demographics," social issues might well dictate that there be an equal mix of men and women for overall prosperity and growth-even if it is not the simplest or cheapest decision.

3. Fair, the right thing to do

Research here focuses on what is the morally proper thing to do, whether or not it is simple to do or in the interests of the majority. For example, fairness may demand that there be sufficient books, videos, artistic and musical materials to suit all represented cultures-even if it is more expensive and not required for overall community welfare.

4. Average/representative/statistically-based/normal

Research here focuses on finding out what is the norm, the average, the statistically representative. For example, under demographics, mathematical ratios might be used to ensure that the colonists statistically represented earth's cultural and ethnic diversity.

5. Sensitive to symbolism/politics/public relations

Research here focuses on making sure that the decision is made mindful of the symbolism, irrespective of any practical, scientific, or moral argument given above. For example, even if the designers can justify the initial crew being composed almost entirely of men from western countries, such a decision would clearly be insensitive to appearances (if not also to fairness).

In filling out and discussing the decision matrix, take your research and consider how each cell in the matrix would need to be filled in to honor each criterion for each of the four topic areas in each of the units. These kinds of decisions will provide important food for thought about how to cast the final proposal to make it successful and get it approved.

<<insert decision matrix for the arts here>>

Notes on the Decision Matrix criteria for the arts:

1. The simplest, minimal, least hassle, cheapest

The design focuses here on coming up with the answer involving the most functionality and ease of installation; creativity is downplayed. For example, the sponsors might simply declare, without any lengthy debate, that all the artwork will be photographs bolted to the capsule.

2. Form follows function

The design here focuses on coming up with artwork that is most appropriate for the physical environment, its materials, shapes, space available, functional role of the art, etc.

3. Most artistically creative

The design keeps creativity and innovation at the forefront of all thinking, irrespective of the difficulty or impracticality of the design.

4. The most popular

The artwork would be subject to voting, focus groups, mass taste appeal, etc.

5. Sensitive to symbolism/politics/public relations

The design work is extra sensitive to the symbolism represented by what is in the work and what is absent from the work. For example, even if the scientific mission designers can justify the initial crew being composed almost entirely of men from western countries, such a decision would clearly be insensitive and perhaps immoral; the artwork would then be deliberately designed to represent the earth's variety.

Life Science Focus

Decision / Criteria	1. The simplest, minimal, least hassle, cheapest	2. Optimal for overall communal harmony, happiness	3. Optimal for individual needs, freedoms, preferences, and differences	4. Fair, the right thing to do	5. Average/representative/statistically-based/normal	6. Sensitive to symbolism/politics/public relations
Water Issues						
Food Issues						
Waste Issues						
Atmosphere						

Social Science Focus Criteria / Decision	1. The simplest, minimal, least hassle, cheapest	2. Optimal for overall communal harmony, happiness	3. Optimal for individual needs, freedoms, preferences, and differences	4. Fair, the right thing to do	5. Average/representative/statistically-based/normal	6. Sensitive to symbolism, politics/public relations
Demographics						
Language						
Culture						
Communication & Group Dynamics						